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The application of technology to libraries, possible library systems of the future, and problems of effecting a transition between the present and the future are examined. The report identifies a series of recognized or assumed service and operations requirements, surveys major technologies applicable to libraries, and reviews current and planned applications of technology in libraries. Particular areas or functions in which technology has not been adequately explored are identified, and estimates are given of the likely role of technology in libraries some five to ten years hence, both with and without some kind of accelerating influence. Some of the issues and problems associated with charting and implementing an effective course of action are examined, and a program of action is outlined and recommended for implementation. The program covers five recommended "high-impact" network systems projects, together with a supporting program of technology-oriented library research, development, education and training. Establishment of a permanent body is recommended to plan and manage these and other programs for nationwide library improvement. (Author/CM)

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TECHNICAL MEMORANDUM

(TM Series)

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TECHNOLOGY AND LIBRARIES

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15 November 1967

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FOREWORD

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1. INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

1.1.1 Purpose of Report

This report on Technology and Libraries has been prepared by System Development Corporation for the National Advisory Commission on Libraries, which has been asked by President Johnson to appraise the role and adequacy of the nation's libraries and to recommend actions that might be taken by public and private groups to assure an effective, efficient library system for the future. The basic objective of the report is to assist the Commission--and, through it, other interested audiences--in examining the applicability of technology to libraries, possible library systems of the future, and problems of effecting a transition between the present and the future.

In accordance with this basic purpose, the project team has endeavored to present as objective and balanced a review of technology as possible, without either overemphasizing or minimizing its achievements or potential.

1.1.2 Scope of Report

This report, one of 17 prepared by various organizations on behalf of the Commission, deals with the relationships between two large domains: libraries and technology. The major types of libraries of concern to this report are public libraries, libraries in educational institutions, and special libraries. (For purposes of this report, state libraries are treated together with public libraries, rather than as a special category.) Some attention is also given to selected library-like information facilities. The technology domain is considered to cover both equipment and techniques that presently have some impact on library systems.

Statements and predictions in this report are based on findings reported in the literature, on interviews, or on SDC staff studies. References are given wherever possible.

A special word regarding statistics is necessary. It is acknowledged that statistics concerning libraries are not wholly satisfactory. Nevertheless, there is some agreement among librarians that the statistics are relatively accurate. The reader is cautioned to interpret any statistics offered in this report in their relative, not absolute, sense.

Some aspects of libraries and technology are given less attention than others, in this report, because they are the subject of other, more complete and detailed commissioned reports (see Figure 1). An effort has been made to exchange outlines, drafts and ideas with other report teams to minimize both omissions and unnecessary duplication.

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Extra-Library Information Dissemination Systems	Mr. DeWitt O. Myatt Science Communications, Inc.

Figure 1. Other Studies in Support of the Advisory Commission

1.1.3 Structure of Report

This report includes an analysis of present and projected library service requirements, a survey of potentially applicable technology, a description of current applications and trends in the use of technology, a prediction of future directions in library operations and services (including a discussion of the problem of planning for transition from the present to the future) and recommendations for a program of action.[1] The appendices describe three kinds of technology related to the library: computer technology, procedural technology, and related equipment and materials technology.

A summary of major findings and recommendations is provided in the next section of this chapter.

1.2 SUMMARY

1.2.1 Present and Projected Library Requirements

The purpose and general character of library services have not changed greatly over the past forty years. What has changed for most libraries is the range and volume of demand and use. The rapid and pervasive growth of specialization in new subject matters, together with an increasingly large and literate user population, have placed severe burdens on libraries of all kinds.

If the nation's libraries are to keep pace with the growing pressures of literature expansion and service requirements, the libraries will need to accelerate and expand some of the programs for library improvement that some of them have already undertaken; and if the libraries are to do more than keep pace--i.e., to provide better and broader service than they now do--a much more aggressive and integrated approach to improvement will be needed.

To bring about a nationwide improvement in libraries, it will be necessary to think in terms of more interdependent modes of operation. It will also be necessary to take better advantage of the developing technology.

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[1] Recommendations are generally confined to those that can be made without full consideration of matters discussed in other commissioned reports. Some of our recommendations relating to technology in libraries may require modification in the light of broader issues, requirements, and constraints that the Commission must consider.

1.2.2 Technology Related to the Library

The domain of technology applicable to the library encompasses such areas as data processing by computers; "procedural" technologies, such as document storage and retrieval, automated indexing and classification, machine translation, automated abstracting, and automated question-answering systems; and a variety of related equipment and materials technologies, including microform techniques, reprography, computer-assisted publication techniques, and materials handling and storage devices and procedures.

1.2.2.1 Computer Technology

The equipment with the greatest potential impact for library operations is computers. Computer equipment is currently available in a number of configurations spanning a purchase range from $6,000 to $10,000,000. While not adequate to meet all of the processing needs of very large libraries, it is quite adequate for a wide range of individual library automation tasks. Barriers that stand in the way of library applications include cost, lack of adequate library-oriented computer programs and associated procedural methodology, too little computer memory capacity, and limitations in the input and output equipment.

The next five to ten years are likely to see at least a tenfold reduction in computer system costs for a given level of performance, while computer speed and storage capabilities will increase severalfold. These changes will accelerate the library use of computers both for "housekeeping" tasks and for assistance to bibliographic tasks.

How much and what kind of computer capability libraries should have is impossible to determine now. Two quite different computer-support concepts present themselves: (1) a large number of geographically remote consoles, connected by data-transmission lines to very large, powerful, time-shared computers; (2) individual use of separate computers of the smaller and less expensive kind now beginning to appear. Both concepts will probably be adopted: time-sharing by the smaller libraries, and "private" computers by the larger, more affluent libraries.

1.2.2.2 Procedural Technology

A number of applications of computers to processing textual material offer promise to library operations. Many operating systems in business, industry, and the military currently store and retrieve data from files. These operations are similar, in some respects, to those required for the storage and retrieval of bibliographic information, and some of the techniques developed for data retrieval work are applicable to types of library data that can be highly structured and formatted. Automatic analysis of non-formatted full text materials is a more complex task, and, accordingly, progress in fully automated retrieval of textual contents lags behind that in formatted data-handling systems.

Fully satisfactory programs for automatic indexing or subject-heading assignment are not yet available; yet, some current systems provide a high degree of automation of other retrieval functions. One system permits users to pose requests directly to the computer system and to receive computer assistance in identifying document representations meeting prescribed criteria. Such systems are not yet within the economic range for use by library patrons, but could be used to provide assistance to library personnel. With decreasing computer costs, more readymade programs, and better-trained library staff, such services can eventually be extended directly to library users, particularly in special or experimental libraries.

Fully automated indexing, classification, abstracting, machine translation, and question-answering must still be considered to be in the research or development stage. However, substantial assistance to library processes is likely to come, in the very near future, from concepts of operation in which the machine serves as an aid, not a replacement, for the librarian or information specialist. Computer-aided instruction is likely to play an important role in training library personnel for work in computer-based systems and in helping patrons learn to use such systems.

1.2.2.3 Related Equipment and Materials Technologies

Microforms--previously valued for reasons of space-saving and materials preservation--are also used increasingly as a medium of communication. Inexpensive microform readers are currently available. During the next five to ten years we may expect the establishment of large-size microfiche collections, and significant improvements in microform technology, including stable color microfilm, sophisticated microform-handling equipment, direct information transfer between microimage and computer subsystems, and ultramicroform technology. The current trends of lowering costs and increasing quality will continue for copying, offset printing, and the printing and reading of fiche.

The advent of photocomposition--computer-controlled preparation of reproduction masters with electro-optical techniques--is very important because it provides libraries with the option to abandon card catalogs in favor of book-form catalogs, up-to-date versions of which could be printed in multiple copies to be available in several locations in the library. The availability of library materials--either text or catalog-type information--in machine-readable form will provide an opportunity to explore other computer applications economically.

Printed materials will be the primary carriers to be dealt with for some years, and few libraries will be able to use electronic means exclusively to manage their information. Texts will have to be stored and handled by humans, aided, in some instances, by mechanical devices. There are some promising materials-handling devices--conveyors, tubes, containers, lifters, stackers, etc.--some of which can be useful in future systems where materials-handling is largely computer controlled. Most of these devices appear too expensive, at present, for widespread use.

Transmission of materials is becoming increasingly important to libraries, particularly in relation to possible network operations. Of the several means for the transmission of materials, mail is currently still the most practical. Efforts are under way to create working systems that employ advanced communications technology to support retrieval of material from a central store, and transmitting it to different places. Both the accuracy and the data-transmission rates of various kinds of telecommunications equipment can be expected to increase in the near future. It is not yet clear whether there will be sufficient equipment compatibility to serve the purposes of highly integrated library networks.

1.2.3 Current Applications and Trends

A number of libraries, primarily the larger academic libraries and special libraries, have begun to use data processing equipment in their operations. All of the major library functions (acquisitions, cataloging, circulation control, serials management, reference work, etc.) are drawing attention. The emphasis is primarily on functions related to technical processes and circulation control, rather than reference services.

Certain aspects of the acquisitions process lend themselves particularly well to data processing, and some groups of libraries have even been exploring the idea of cooperative or centralized processing for some aspects of the acquisitions process.

The most popular application of technology in the cataloging process has been to reproduce catalog cards. Book catalogs, frequently used many years ago but abandoned in favor of card catalogs, are returning to favor, with the help of the computer and computer-controlled typesetting procedures. In cataloging, as well as in acquisitions, the combination of interlibrary cooperation and new technology offers great potential for the reduction of costs and wasteful duplication of effort. The Library of Congress MARC Project, which is a prototype of a national network for the distribution of machine-readable catalog data, provides an example of this potential.

Data processing technology is being used for a variety of tasks associated with circulation control, and a few institutions are beginning to work toward the development of on-line operations that will tie a circulation control system directly into a computer at all times. Such a system will bring libraries a step closer to still another feasible approach, that of operating circulation control systems on a network basis within a region.

A number of projects are under way to use data processing for serials records control. Few institutions, however, have operational systems, and those that exist do not perform all the necessary functions of serials management. The project at the Library of Congress to determine what elements of information should be put into machine-readable records for serial titles can provide a valuable framework on which individual libraries can build and through which they may eventually participate in regional or national serials projects.

In comparison with other library operations, the reference function shows very little in the way of applications of technology, for most libraries. Very few libraries have automated their information and document retrieval functions. There are a few primitive automated data retrieval systems, but they are nearly all in information centers, not libraries.

Technologies other than data processing are being put to use in libraries. Microforms are being used increasingly, but their vast potential still seems to be untapped. Materials-handling equipment, specialized communications equipment, storage equipment, etc., have all found some use in libraries, but such use has largely involved the adaptation of equipment and procedures developed for other purposes, rather than especially tailored to meet library needs.

Many libraries have looked to technology to reduce costs or to hold them constant. Cost consciousness sometimes has not been extended to consider the effect of changes on the users of libraries: some ostensible cost reductions may "cost" the users more than they save in time, effort, or even money.

Technology offers an opportunity to provide access to and services for non-monographic materials of all kinds as good as those that have been furnished for printed monographs. There are also indications that use of technology may allow new services to develop in libraries to serve certain user groups better. Technology may also provide means of improving the organization and management of libraries.

At present, only about three percent of the approximately 24,000 libraries in the U.S. are using data processing equipment. One can foresee that, in the future, many more libraries will seek to use such equipment, especially computers. Much of the effort is likely to be focused toward particular problems in particular libraries. Much more coordination would be desirable to channel these disparate efforts into a national effort that would bring all aspects of our technology to bear on the problems of library operations.

1.2.4 Future Directions in Library Operations and Service

There are two different approaches toward prediction of the nature of the library of the future. One approach stresses the continuation or extrapolation of current trends. The other approach stresses what it is theoretically possible to achieve. Both approaches are useful: the first is useful in short-range planning, because it takes adequate account of the problems of transition, and the other takes note of distant goals, which helps to broaden the horizons of one's thinking.

An extrapolative view, which assumes no major acceleration of effort, sees the large majority of libraries operating much as they do today, over the next ten years. In spite of continuing improvements undertaken by libraries, there will probably not be any net gain in service for the majority of individual libraries. Indeed, some deterioration of service is likely to occur, because of the vast increases in published materials that must be dealt with. Large categories of nonbook materials will continue to be neglected, to a great extent. Without some form of accelerated planning and support, the majority of libraries are not likely to be able to participate in or benefit from emerging network arrangements.

A conditional view of library activities, which assumes major acceleration of effort over the next ten years, sees libraries becoming elements of one or more integrated networks. Through a connection with a network, libraries could provide their staff personnel with better tools, with relief from some processing chores better handled through the network, and with network-supported facilities for handling reference problems. The library's users could also be provided with much more in the way of materials and services, with outright distribution of certain kinds of materials replacing loans. The availability of nonbook materials could be increased in libraries of all kinds and sizes across the nation.

There are a number of problems of transition from the present to the future that are not entirely technological in nature. Libraries, already facing serious staff shortages, may find it very difficult to obtain staff with the broad training and experience necessary in both the requirements of library operations and those of technology. Too, library users will need better training in exploiting available library services and facilities. Here, technology itself offers some promise of providing useful tools.

Standards of operation, as well as standards necessary for the compatibility of bibliographic data, are still lacking in the library world. As new data files are created and old files are converted, this problem will become more serious. The several possible approaches to standardization need active consideration, if the many separate and independent library organizations are to achieve adequate cooperation and communication, using the newer technologies.

1.2.5 A Program of Action

Several approaches offer themselves for the improvement of the nation's libraries. One is to depend on the mechanisms already being used to improve library operations and service, without attempting to accelerate the rate of improvement. This approach requires no drastic change in present activities, concepts of service, funding, or patterns of involvement of the Federal Government. On the other hand, most libraries would almost certainly continue to lose ground, in the face of increasing processing loads and demands for service.

A second approach would be to plan and attempt to develop a nationwide, highly integrated library system. Such an approach would permit certain kinds of system-wide operations that are not likely to evolve otherwise. It would also reduce duplication of effort by many individual libraries. On the other hand, this approach has some very stringent requirements--e.g., common, agreed-upon goals and strong "top management"--that might be difficult to meet at this point in time.

The third approach--which this report recommends--focuses on more limited goals and subsystems or networks and attempts to identify and support selected high-impact projects. This approach recognizes the operational independence of most of the nation's libraries while at the same time taking advantage of their willingness to participate in interdependencies that offer mutual benefits. The approach also has the advantage of not precluding the undertaking of other projects and programs.

Some high-impact projects could and should be aimed at the development of model subsystems that could later be incorporated into a more fully integrated, nationwide system. Five such projects are recommended for consideration:

- A Prototype of Regional Libraries
- An Expanded, Computer-Based National Union Catalog
- A National Bibliography
- A National Referral and Loan Network
- A National Library Storage and Microform Depository System

Undertaken together, these projects could lead to operational systems in from two to four years.

While these high-impact projects are dependent on technology and while they involve subsystems that will eventually be important in extensive, technology-dependent national networks, they do not contribute directly to the exploitation of technology by individual libraries. It is recommended, therefore, that concurrent with the operations-oriented projects, a comprehensive program of technology-oriented library research, development, and education and training be undertaken. It should encompass Hardware Specification and Development, Procedural (Software) Specification and Development, Direct Supporting Research, and Education and Training. Also recommended for consideration, as part of this program, is establishment of a test bed for handling new forms of nonbook materials.

Before such activities can or should be undertaken, several things must be done. They are offered as the primary recommendations of this report.

1. THE BASIC APPROACH OF USING HIGH-IMPACT PROJECTS, TOGETHER WITH SUPPORTING RESEARCH, DEVELOPMENT, AND EDUCATION AND TRAINING, SHOULD BE EXAMINED AND, IF POSSIBLE, ENDORSED AS THE MEANS BY WHICH LIBRARY IMPROVEMENT WILL BE SOUGHT DURING THE NEXT FIVE TO TEN YEARS.

2. THE PARTICULAR HIGH-IMPACT PROJECTS AND R&D REQUIREMENTS OUTLINED IN THIS REPORT SHOULD BE EXAMINED BY THE COMMISSION AND BY OTHER INTERESTED MEMBERS OF THE LIBRARY AND INFORMATION SCIENCE COMMUNITY, IN THE LIGHT OF OTHER ISSUES, REQUIREMENTS, AND CONSTRAINTS, TO DETERMINE WHAT PRIORITIES THESE AND OTHER POSSIBLE PROJECTS SHOULD BE ASSIGNED AT THIS TIME.

3. FOR THOSE PROJECTS SELECTED FOR IMPLEMENTATION, ARRANGEMENTS SHOULD BE MADE TO DEVELOP MORE DETAILED OBJECTIVES, TOGETHER WITH PRELIMINARY COST APPRAISALS AND IMPLEMENTATION SCHEDULES.

4. FOR THOSE PROJECTS SELECTED FOR IMPLEMENTATION, ARRANGEMENTS SHOULD BE MADE TO IDENTIFY ALL POTENTIAL SOURCES OF SUPPORT AND, AT THE APPROPRIATE TIME, OBTAIN THE FUNDS NECESSARY TO CARRY OUT THE PROJECTS AND PROGRAMS SELECTED.

5. RESPONSIBILITY FOR CARRYING OUT THE ACTIVITIES INDICATED OR IMPLICIT IN THE FOREGOING RECOMMENDATIONS SHOULD BE PLACED AT A HIGH ADMINISTRATIVE LEVEL IN AN EXISTING OR NEW AGENCY OF THE FEDERAL GOVERNMENT OR IN A PUBLIC/PRIVATE BODY CREATED FOR THIS PURPOSE.

The last recommendation is of particular importance. The need for assessment and planning for libraries will not diminish or disappear once the present Commission presents its report. To insure that effective planning and implementation continue, a permanent body is needed that can be responsible for: (1) keeping informed on the existing and prospective state of library service and operations, (2) planning for improved library service at both national and local levels, (3) developing legislative proposals, (4) coordinating various projects affecting library service, and (5) planning and coordinating financial support, from both the public and private sectors.

Of the several possibilities that suggest themselves for such a permanent body, the most attractive one involves extension of the life of the National Advisory Commission. This would help to insure continuity of thinking and planning and would take advantage of the interest, expertise, communication, and working arrangements developed by the Commission. The Commission would need to be supported by a highly capable, full-time technical staff, some of whose members might be drawn from the Government or private sector for extended periods of time.

Whatever the planning mechanism adopted, it is critically important not to lose momentum. A sizable and indeterminate time gap between the Commission's work and the development and implementation of an action program could itself foster a paralysis of planning on the part of the libraries and might lead to yet other status surveys covering much the same ground as the present Commission has covered. While technology and the needs for library service are certainly changing, the changes are not so rapid or erratic that they should encourage a succession of independent assessments. The need for library improvement is clear, and so is the potential contribution of advanced technology. Aggressive, concerted, and timely action should be taken now to effect a nationwide improvement of our libraries.

2. PRESENT AND PROJECTED LIBRARY REQUIREMENTS

2.1 KINDS OF REQUIREMENTS

It is widely accepted that people have needs for library services, i.e., access to books, serials, reports and other library materials, and/or the information contained in them. Satisfying those needs imposes requirements for the design, construction, operation, and evolution of library systems. "Requirements," in system design terminology, are formal statements describing functions that need to be performed to allow a specific set of objectives to be met.

There are several categories of library users, whose needs differ greatly from one to another. These needs, in turn, imply several kinds of requirements for different kinds of library services. From the perspective of a given library serving a given public, it is useful to distinguish three related types of requirements:

1. Requirements for direct service to users;
2. Internal operational requirements, essential for rendering direct service in a library;
3. External operational requirements, i.e., requirements for interfacing with external systems of libraries and other information-handling organizations.

Figure 2 illustrates typical requirements for direct service to library users, and Figure 3 lists the major internal operational requirements or functions associated with the satisfaction of user service requirements. Both of these kinds of requirements appear much the same as have always pertained to library operations. This is because, at least in the U. S., the purpose and character of library services have not greatly changed over the past forty years. What has changed for most libraries is the range and volume of demand and use, including the demand for faster and more accurate response.

Some of these needs cannot be met easily, if at all, by improvements in internal operating techniques. Rather, they require consideration of new and more complex forms of interlibrary dependency. Thus, increasing attention is now being paid to the external operational requirements of libraries. For a given library, these requirements may involve a series of dependencies on the existence of several different kinds of networks, e.g., of libraries, publishers, and communications.

1. Browsing access to library materials
2. Searching access via catalogs, indexes, and other reference tools
3. Question-answering service
4. Directive service for reference or referral
5. Reading guidance
6. Instruction in use of catalogs, indexes and other reference tools
7. Reading, viewing and listening facilities
8. Bibliographic compilation
9. Reproduction of materials (copying facilities)
10. Loan and interlibrary loan
11. Discussion groups
12. Story telling and readings to users
13. Paging and other delivery services (e.g., bookmobiles)

Figure 2. User Service Requirements

1. Acquisition of Materials

   Selection and bibliographic checking
   Gifts and exchanges
   Ordering and accounting
   Receiving and disbursing
   Transaction recordkeeping and filing

2. Cataloging

   Bibliographic checking
   Descriptive cataloging
   Classification and subject cataloging
   Marking and labelling
   Card ordering, reproduction, and/or printing
   Announcement and dissemination
   Recordkeeping and filing

3. Storage

   Shelving and other storage media
   Preservation and protection
   Locating and arranging
   Retrieval and replacement
   Inventory and recordkeeping

4. Management

   Planning, organizing, supervising, delegating
   Coordinating, reporting, budgeting
   Personnel selection and training
   Record keeping and statistics
   Maintenance of physical plant, facilities and equipment

Figure 3. Internal Operational Requirements

2.2 PRESSURES FOR LIBRARY IMPROVEMENT AND EXPANSION

Changes in demand and use have been particularly observable in the production and use of scientific and technical documentation. Since World War II, a dozen new technologies have emerged, and a tremendous volume of invention, research, and discovery reported along the way. In the 1950's, thanks in part to changes in the nature of national and international political and economic interdependence, the character of scholarship in the social sciences began to change as well. There has been a shift in the character of demand and use of documents in the direction of far more comprehensive coverage of wide-ranging subject matter. These changes, of course, have been accompanied by a large increase in the number and variety of specialist and general library users and in the variety, range, and volume of documents produced.

So pervasive have these changes been that it has become customary to speak of the "information explosion," the "information deluge," etc., and any report on library problems that does not take notice of this phenomenon may be thought to be lacking in perspective. Although quotations can be found from learned and famous men of the distant past that also bemoan the condition of too much written material for men to cope with, it is clear that the proliferation of publication, the fragmentation of knowledge, and the synthesis of older fields of learning into new fields are placing increasingly severe burdens on libraries. This is particularly true for the larger research libraries. Their book budgets have needed to be enlarged to purchase materials from dozens of new countries as well as old; staff personnel must be sought who can catalog publications in dozens of exotic languages; and new research institutes have demanded specialized information services. What seems to be clear--"information explosion" or no--is that really good libraries can save their users a great deal of valuable time and effort in dealing with recorded knowledge.

It is important to recognize that there are hundreds of smaller libraries around the country that have not changed perceptibly for the last 30 years. The information explosion seems not to have had much effect on these libraries. We must then ask the question, "Should the larger libraries (most of which are part of academic institutions) receive the major part of the national attention, or is it also a national problem that so many smaller libraries have not felt great impact from the continuing increase in publication?"

2.3 PRESENT AND PROJECTED DEMAND FOR SERVICE

2.3.1 Public Libraries

It is estimated that in the year 1967 the more than 6700 public libraries[2] in the United States will have circulated 430,000,000 volumes to some 55,000,000 borrowers (23). The holdings of only a small percentage of these libraries are represented in the National Union Catalog or the Union List of Serials. There are no comprehensive union catalogs available for any type of library for documents, reports, and many other categories of library materials.

Over the next ten years one may expect the number of potential public library users, i.e., those who might use a given library, to more than double, and the character of that user population to change in the direction of a much more literate and highly educated set of customers, whose needs and demands on library services will be much more specialized and varied than they now are (11). If these demands are to be met, the public libraries must implement specific means to meet them. These libraries, as nodes in national networks, must also develop mechanisms both for internal operation and for interfacing with (i.e., participating in) the networks that alone can enable them to identify, locate, and obtain all the materials that can satisfy their public's needs.

The requirements for building and operating mechanisms capable of meeting these service demands include the development and operation of automated procedures for the support of acquisitions, cataloging, circulation, reference, and managerial functions that provide for effective internal operation and compatible communications with other library systems and networks. These imply, in turn, requirements for developing and maintaining standards for operations common to libraries, and for organizing the necessary planning and coordination.

2.3.2 Educational Libraries

Educational libraries may be usefully divided into elementary and secondary school libraries on the one hand, and college and university libraries on the other.

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[2] State libraries are public libraries in many respects, and most of this discussion applies to them equally as well as it does to the more typical public library of a city or county.

2.3.2.1 Elementary and Secondary School Libraries

Total enrollment in the United States for 1966, for kindergarten through grade 12, has been estimated at just under 50,000,000 students (23), with the ratio of elementary students to those in secondary schools being roughly 3 to 1. School libraries typically contain small general collections of books geared to minimum-to-moderate levels of literacy and knowledge, a few periodicals, sizable pamphlet collections, and other special library materials.

Although nearly all secondary schools and over 90% of the secondary school libraries are served by personnel having six or more hours of formal library science training, the number of libraries served by fully qualified librarians is much smaller. A great proportion of the library service demands of elementary and secondary school students continue to fall upon public libraries, either because of the lack of school libraries or the limited hours of service, limited size of collections, and limited capacity of personnel to meet reference, referral, and guidance needs.

A great improvement in potential response to current student demands might be effected, particularly in the larger metropolitan areas, if technical processes were centralized and adequate communications for reference, referral, and sharing of literary resources were organized among and between all school districts in the area. This would require applications of data processing and communications technologies as well as a reorganization of work. Applications of these technologies would also make it possible to improve the state of knowledge and skill of school librarians, through various kinds of on-the-job training programs.

Development of a library service that is appropriately responsive to increasingly high standards of education will require a different kind of access to library resources than is now available to most school libraries, particularly access to library materials of many collections, and to the knowledge and reference skills of a range of library personnel. This, in turn, requires going beyond the boundaries of the school system to share library resources with many libraries. Too, it may require--if only for reasons of cost--extensive use of microforms and other non-book materials, which could help to broaden the school library's resources. Large collections, reduced to microform and adequately cataloged, could be reproduced relatively inexpensively, if done in large quantity, i.e., several thousand sets.

2.3.2.2 College and University Libraries

What has been said here concerning public libraries often applies as well to college and university libraries. Current demands for college and university education imply requirements for library support that can be met fully by only a small minority of libraries in these institutions. Even these few libraries have had difficulty in serving their user populations adequately, with the rapid expansion of demand in volume and variety that has occurred over the past ten years. Another feature in common between the public and college sectors is that, while there is a steady increase in the annual number of volumes acquired and the number of serial titles subscribed to, there has been a steady drop in the number of library items available per library user (23).

As of 1967 it is estimated that there are some 7,000,000 students and faculty in colleges and universities to be served by college libraries. New library buildings in these institutions until recently have been constructed at the rate of about 50 per year, but current plans call for some 1200 buildings to be constructed by 1970 for two- and four-year colleges. In ten years one may expect some 14,000,000 students (not counting faculty) in the institutions and a doubling of the current volume of library materials being acquired (66). There are additional pressures on those libraries of academic institutions that aspire to the title "research library." Library operations to support graduate programs, faculty research, and post-doctoral researchers are much more difficult and costly--perhaps twice as much--than operations to support undergraduate teaching. All of the foregoing implies that the ability of individual libraries to serve their customers will decline, if the current trend continues. There is, even now, a need for making the wealth of library materials and services concentrated in relatively few institutions available to the nation's library users. This can be accomplished only through the further development and application of advanced information handling and communication technology to individual libraries and to library networks.

2.3.3 Special Libraries

It has been estimated that there are more than 6,000 special libraries[3] in the United States, including government, society, business, and industrial libraries (with some overlap with university libraries). As of 1965, it was estimated that these libraries account for expenditures of some $189,000,000 per year, as compared with $267,000,000 for public libraries and $229,000,000 for college and university libraries (23). In short, there are nearly as many special libraries as public libraries, and operational costs are about two thirds those of public libraries.

Because of the changes in the direction of research, development, and ancillary activities from subject-oriented work to mission-oriented work, which cuts across traditional disciplines, the special library has found it increasingly difficult to collect widely enough to gratify its user demands and, even more importantly, to serve its potential user population. Even today, many special libraries have been able to satisfy their clientele only because they are able to fall back on the resources of nearby academic libraries. Such use constitutes a heavy burden to more than one academic library.

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[3] Special libraries are considered to be those libraries that concentrate upon highly specialized collections of materials and serve special groups, largely of highly educated and trained specialists in a subject area.

The current state of copyright matters leads to a certain amount of uncertainty in projecting requirements for library systems and networks of the future. The present copyright law was written before there were ready means of making copies in libraries, other than by hand or by rather cumbersome photographic means. Over the years, as copying devices appeared that were easy to use and relatively inexpensive, a doctrine of so-called "fair use" developed, outside the copyright law. The doctrine of "fair use" has worked reasonably well, but many practicing librarians are well aware of abuses in the system, especially where copying machines are not monitored by the library itself. Since this report addresses itself to technology, it is perhaps best to confine our comments to observations of the effect that an increasing number of copying devices will have on the libraries of the future. Such devices will become more common and will cost less to use, and the quality of copy will improve. Under pending legislation, it would appear that future library systems and networks would have to provide for contracting, accounting and compensating mechanisms to pay owners of copyrights. No one will predict how a new copyright law will effect such library operations as telefacsimile transmission and other rapid copying methods. It seems likely, however, that there will be at least some categories of material for which library systems and networks will have to provide compensation to the owners of copyrights for copying and other usage that would, without compensation, constitute infringement.

If it is a basic objective to satisfy the needs of all library users in the United States, present and future, a way must be found to ensure that the needed documents are available to them. Since there is no way, a priori, to judge the utility of documents to potential users, all potentially useful documents must be sought. The basic considerations for a system with this capability are:

1. The networks must be so constituted as to ensure that there exists within the United States at least one accessible copy of the published documents produced in the world--past, present, and future.

2. The library systems and networks must provide appropriate mechanisms for acquiring, announcing, processing, searching and making accessible the library holdings of the nation to library users throughout the country.

3. The library systems and networks must provide for contracting, accounting, and compensating mechanisms to pay the owners of copyrights for copying and other usages that would, without compensation, constitute infringement of copyrights.

It is recognized that the goal stated in the first consideration can only be approximated, because it certainly cannot be known what documents exist at any point in time. The notion of "accessible" implies further techniques to ensure that the existence of documents be widely known and the documents themselves, or facsimiles thereof, made available to users throughout the country in an economic and timely fashion.

The second consideration implies a great expansion in the creation, timely updating, and dissemination of union catalogs, union lists, special bibiographies and indexes to library collections. It also implies a great increase in the availability of document facsimiles via microform, machine-readable files, or other reproduction facilities. Copying, in turn, implies a need to deal effectively with holders of copyrights.

It is true that many of the pioneering efforts in automation of library processes have occurred in special libraries and that many of the most highly automated libraries are in this category. These, however, constitute a very small minority of special libraries. As with projections for public and educational libraries, the increase in the volume and variety of materials, as well as the trend to more specialized use of materials, indicates that if current trends in library development and practice are continued without acceleration and without a concomitant development of viable national networks, special library users of the future will not be served as well as they are today.

2.4 IMPLICATIONS FOR INTEGRATED LIBRARY SYSTEMS

The foregoing discussion of present and projected demands for library service points to two primary conclusions: (1) if the nation's libraries are to keep pace with the growing pressures of literature expansion and service requirements, the libraries will need to accelerate and expand some of the programs for library improvement that some of them have already undertaken; and (2) if the libraries are to do more than keep pace, i.e., to provide better and broader service than they now do, a much more extensive and integrated approach to improvement will be needed.

The external requirements for all the libraries, taken together, point to the need to develop networks, construed here as functional dependencies whose mechanisms provide for the transfer of messages and/or material within and between library systems and subsystems. In order to plan for and operate such networks, there must be agreement among the participants on certain desiderata of library services.

It appears very unlikely that the operational requirements implied by the foregoing desiderata can be met by the techniques in current use. More extensive application of advanced technology will certainly be required. There will also need to be a shift toward more interdependent modes of operations. If the transition from current practice toward more automated and interdependent operations is to be an orderly one, there will probably need to be an organized body or agency that exercises responsibility for planning and coordinating such transition and for seeing that the network operations are economical and effective in meeting the nation's requirements for library service. Without such coordination, wholly effective network operations will not come into being. (This problem is discussed in Section 6: A Program of Action.)

In discussing requirements, it is important to keep in mind that many of society's requirements are "created," rather than "pre-existing." Thus, current accepted requirements for such things as telephone service, air transportation and computer support stem, at least in part, from the very availability of the services involved. In the same sense, "requirements" for library service should not be thought of as entirely pre-existing and stable. The availability of better library service will necessarily reinforce and intensify the demands for higher standards in the nation's libraries. The important implication from this is that the requirements and desiderata for improved library service should not be too narrowly conceived or too closely tied to present limitations, lest the system or systems developed to meet them become obsolete almost as soon as they are completed.

3. TECHNOLOGY RELATED TO THE LIBRARY

The domain of technology related to the library is wide, encompassing not only data processing--perhaps the most obvious kind of technology--but also computer-assisted publication techniques, materials handling and storage devices, microform techniques, and reprographic devices. It also includes a variety of "procedural" technologies such as document storage and retrieval, automated indexing and classification, machine translation, automated abstracting and automated question-answering systems.

This section of the report briefly reviews some of the more important technologies that are having, or are likely to have, an impact on library systems of the future. The same topics are covered in greater detail in the three appendices to this report.

3.1 COMPUTER TECHNOLOGY

3.1.1 Introduction

Of all equipment represented by modern technology, the kind with the greatest potential impact for library operations in the next five to ten years is electronic data processing equipment, specifically, computers. These devices, together with associated equipment and procedures, offer the capability for relieving some of the serious technical processing problems of library systems and, eventually, for upgrading the range and quality of reference and retrieval service.

There is a wide range of computer equipment currently available, with various configurations spanning a purchase range from $6,000 to $10,000,000. These configurations can be thought of as consisting of five components:

Central Processing Units (CPU)
Main Memories
Mass Memories
Peripheral (Input/Output) Devices
Terminal Devices

3.1.2 Status of Computer Components

Most Central Processing Units have been built for problems of scientific computation or business data processing, rather than for problems of library automation. Nevertheless, these units are more than adequate to handle most of the problems of library data processing. The barriers that stand in the way of library automation are not technical inadequacy of the CPU, but price, lack of adequate software, too little peripheral memory capacity, or limitations in the input/output equipment.

Main memories--internal storage--are generally of adequate size to handle library problems, and their cost has decreased considerably in the past 15 years, from $1 to 25¢ per bit. Bulk storage devices have greater capacity and lower cost than main memory, and provide external storage for large quantitites of data that are read into the computer through the internal storage device. Magnetic tape has been widely used as a mass storage device but is being replaced by faster-access devices, such as drums and discs, and research is underway on even more sophisticated devices, as well as on "content-addressable" memories, all of which could see wide use in libraries. Yet, because of its versatility, magnetic tape will probably be the main mass-storage device in the automated library of the near future. A typical 2400-foot tape can hold the equivalent of over one million English words, and the present cost of tape for tape storage is only about .015¢ a word. Drums require less access time than tapes, though they also have a smaller capacity (up to 333,000 words) and cost is around 3¢ a word. A disadvantage is that the drum cannot be removed from the computer. About the same cost per word is estimated for disc storage, which has the advantage of now being available in a disc pack, thus giving non-serial accessibility of the disc. The disc pack will probably be used heavily for any changing data required in library operations.

Developments in optical storage techniques, such as the "photoscopic disc," continue to be promising. Such techniques, introduced several years ago, are expected to provide capacities of billions of words, at about .03¢ a word, and to permit updating of information by a photocopying operation. This will be relatively slow but may be well-suited to fairly stable sets of library information such as dictionaries or authority files. And library retrieval will benefit greatly if economical associative memories are developed--memories in which retrieval will be based on coincidence of part of an input pattern with part of the stored reference pattern.

Input/output (I/O) equipment available includes cards, tapes, and the new scanning equipment. Cards are still the most widely used for input; they allow changes in a program to be made easily, but are slow, and limited to one type font. Paper tape is increasingly used for input, because it transmits rapidly, but not for output, because there it is slow, difficult to search, and fragile. Magnetic tape is less fragile and can be used in high-speed typesetting. Optical readers scan pages of text and write it out onto tape or card or directly into the main memory. Progress is being made in the development of these optical devices, and they hold great promise for use in libraries of the future. Some can read a variety of fonts, and they will probably see heavy use as a substitute for a keypunch to handle the high volume of data in a library.

Terminal devices are used for man-machine interaction in "real time," and fall into two classes: the relatively inexpensive typewriter-like device, and the more expensive, sophisticated console with a cathode ray tube. They may be connected to a computer either by leased-line or by economical dial-up service.

The most commonly used terminals are keyboard devices, like typewriters, which are connected to telephone lines by a device called a modem (modulator-demodulator) or an audiocoupler. Pushbutton touch-tone telephones are also being used for input of data to a computer. A Model 33 teletype costs only about $470, requires little training in its operation, and can be located thousands of miles from a computer.

Cathode ray tubes (CRTs) range from something that resembles a 14-inch television set with keyboard, to the large, sophisticated device that has graphic capabilities, a light pen that triggers displayed data or allows the user to write on the screen, and a number of other features. Both types of console are used at or near the computer; microwave links or video cables will probably be required before remote use is possible.

Other types of I/O equipment include a new device called an audio response unit, and a set of equipment that permits converting pictures to digital data and transmitting them to the computer, and the reverse.

3.1.3 Future Developments and Computer Uses

Not all of the needs of very large libraries could be met with the equipment described above, which still features capacities and speeds that would be inadequate for some sophisticated automation efforts involving massive amounts of data. Yet, most library automation tasks could be accommodated on the modern computers, and projected cost reduction and technological innovations (e.g., in optical readers) promise substantial use of automation in future libraries. In other words, there exists a wide range of computer systems and components that may be applied to library information processing.

The next five to ten years are likely to see at least a tenfold increase in computer capabilities, measured in speed and amount of data stored and processed. For a given level of performance, computer system costs are likely to be only about one tenth of what they are today. These predictions do not depend on the assumption of spectacular technical breakthroughs.

In addition, more equipment specifically designed for handling textual data will probably be developed, for example, CPUs for list processing programming languages, or associative memories that increase the facility with which computers can handle information-retrieval type work. As the cost of computer circuits continues to decrease, and as production levels increase, it may still be more economical to use general-purpose computers of standard design than special-purpose computers.

Perhaps the most significant development for libraries will be the advent of very large memories. There is every reason to expect that one of the many forms of large memories--whether it be photographic, laser-written, or of electronic beam technology--will be able to handle files of at least 10^{13} bits (333 billion words). The advent of such files will provide the stimulus necessary to develop the software required to handle large files. If breakthroughs are necessary anywhere, it is in this area of software. Many expensive systems with sophisticated hardware are still operating as though they were faster versions of punched card systems.

In line with other cost reductions, consoles should become much less expensive. In principle, the console should not cost much more than a television screen and a keyboard. The advent of the small, powerful, and inexpensive computer will allow much of the circuitry presently housed in today's expensive consoles to be transferred to an intermediate computer.

Computers may be used in the library in two ways: for clerical tasks (e.g., some portions of acquisitions, cataloging, circulation, and serials management) which will free librarians for other professional functions; and to provide added capability in performing bibliographic tasks. This added capability, in turn, breaks down into two different categories. First, bibliographic material will be processed so that it can be more easily retrieved, as needed, by library or user personnel. Thus, it might include such activities as automatic indexing, automatic classification, and perhaps automatic abstracting. Second, the library user will be given tools for interacting "directly" with the information store and searching it for documents and data of interest.

How much and what kind of computer capability libraries should have is impossible to determine now, particularly since two quite different computer-support concepts present themselves. One concept involves a large number of geographically remote consoles, connected by data-transmission lines to very large, powerful, time-shared computers. The other concept is that of using the small and inexpensive (but powerful) computers that are now beginning to appear. This school of thought forecasts that computers that would have sold for close to a million dollars in the past will--in the next few years--be available for only $25,000.

Both concepts will probably be adopted: time-sharing, by libraries that cannot afford a $25,000 piece of equipment; and the use of a small but powerful computer by a more affluent group. Time-sharing will probably also be part of the really giant computers that will be used by very large and affluent organizations. From a library point of view, one might expect to see small private computers in the medium-to-large libraries; large time-shared computers in information systems within the Federal Government; and large time-shared computers, with inexpensive consoles, serving a large number of libraries (the computer utility scheme mentioned above).

3.2 PROCEDURAL TECHNOLOGY

3.2.1 Introduction

There are a number of applications of computers to textual material that either provide current capability or offer promise of support to library operations. These include document storage and retrieval, automated classification, automated indexing, machine translation and automated abstracting, and automated question-answering systems. A great deal of research and development work has been carried out on these techniques, and in some of them there has been substantial progress. A number of library-relevant techniques are available for use. (See Appendix B for greater detail.)

3.2.2 Storage and Retrieval Systems

Many systems are in operation, in business, industry, and military operations, for the storage and retrieval of data from very large files. Although these systems were not developed primarily with books in mind, the techniques used are similar, in many respects, to those required for the storage and retrieval of text. Current work in data systems centers not so much on the technical feasibility of large "data base" operations as on the relative efficiency of various file organization and search techniques. The principles, techniques, and programs developed for data retrieval work are applicable to those kinds of library data that can be highly structured and formatted, e.g., authority files.

Document retrieval systems--i.e., systems for handling textual information--presently lag far behind data-handling systems in the application of data processing techniques. Most of these systems require that humans analyze material entering the system and prepare representations of it for computer storage. Some kinds of automatic indexing that are both technically and economically feasible--for example, permuted indexes of titles--have not yet proved adequate to meet the search needs in most document storage and retrieval systems. Given the need for human indexing, however, some current systems provide a high degree of automation thereafter. One system operated under the auspices of the Federal Government permits a large number of users, at widely dispersed locations, to pose requests directly and simultaneously to the computer system and to receive computer assistance in identifying document representations meeting prescribed criteria. Such systems are not yet within the economic range for use by library patrons, but they could be used in connection with various kinds of special files to provide assistance to either technical processes or reference personnel. With decreasing computer costs, more ready-made programs, and better-trained library staff, such services are well within reach of extension directly to library users, particularly in some kinds of special and educational libraries.

In the next five to ten years, we may expect to see the development and application of acceptably efficient computer aids to human indexing and classification, using machine-readable inputs that are provided by optical readers or that are by-products of publication. Techniques of file organization and search, currently lagging behind equipment technology, will probably keep up reasonably well with the increasing demands placed on them by the very large files that new equipment techniques are providing. Too, the present somewhat embryonic techniques for direct interaction with the file--already accepted in the intelligence community and increasingly mentioned in "libraries of the future" discussions--can be expected to become relatively commonplace in research-type libraries that can afford some degree of computer assistance.

Although many technical problems must be overcome to make substantial inprovements in document storage and retrieval techniques, cost may be a more serious problem. The widespread applicability of document storage and retrieval techniques is heavily dependent on success in providing cheaper and more powerful computer equipment.

3.2.3 Component Techniques

Most of the specialized techniques associated with document storage and retrieval--automated indexing, classification and abstracting; machine translation; and question-answering--must still be considered in the developmental stage. Within some of these areas, however, sufficient progress has been made to provide potentially effective tools for library use. The status and prospects in each area are summarized below.

3.2.3.1 Automated Classification

Thus far, studies have shown that computers can be used to generate classification categories that look "reasonable" and that one can achieve a moderate amount of agreement between human and computer sorting of documents into prescribed categories. Nevertheless, there are no fully automated systems available yet, and the relative merits of automated classification are yet to be demonstrated.

The need for computer assistance to classification will undoubtedly continue to grow as collections grow and as more materials become available in machine-readable form. Yet, because of the fairly slow rate of progress in classification research, the most likely applications of automated classification in the near future are likely to be for sensitizing machine-based systems periodically to changes in the character of the collection. By 1975 we may expect to see more extensive applications of automated classification, for example, to "suggest" assignments to the human classifiers. This kind of joint, man-machine document assignment has considerable promise.

3.2.3.2 Automated Indexing

The term "automated indexing" refers to a variety of computer-based procedures, varying in complexity and potential utility to libraries. The simplest kind, which produces permuted indexes, has found widespread use, though more in connection with technical information systems than with libraries. On the other hand, the automatic selection or assignment of index terms from text, originally viewed with optimism some year ago, is increasingly recognized to be a difficult challenge. Fully automatic, high-quality indexing does not yet appear to be within reach, a fact which has led to increasing interest in computer-aided indexing, i.e., man-machine cooperation. Capability to provide a number of useful aids to human indexing is already well within the state of the art. Exploitation of this capability will depend on evidence regarding its likely economic value.

Within three to five years, one may expect to see widespread use of computer aids to indexing in most information facilities that have access to a computer. One may also expect to see, in many systems using text that is already in machine-readable form, index terms directly "suggested" through computer analysis of text. The quality of present-day automatic index term extraction does not appear to compete with the best human indexing, nor does it seem likely to do so in the near future. Nevertheless, expected advancements in the understanding of language and of human indexing itself seem very likely to support a gradual increase in the acceptability of computer-selected index terms.

3.2.3.3 Machine Translation and Automated Abstracting

Both machine translation and automated abstracting involve processing of the full text of documents and the use of statistical, syntactic and semantic tools to effect a conversion of the parent document into some other form--in one case a translated version and in the other, a condensed representation of it. Although work in both these areas started out optimistically several years ago, the analysis of language has proved to be much more difficult and complex than was anticipated. Thus there is virtually no present applicability of either technique to libraries, except in a few special circumstances where there is ready availability of a machine-readable record and a willingness to use abstracts and translations as indicators of important information, rather than as conveyors of substantive information.

The future of both these areas is highly problematical, since improvements are very dependent upon progress in other more fundamental parts of language processing. Since, too, author-produced abstracts are increasingly being requested for submission with reports and articles, the need for automated abstracting, at least, may be diminishing. Given these considerations, there seems little likelihood that the use of these techniques will become attractive to most libraries.

3.2.3.4 Question-Answering Systems

Question-answering systems provide a rather direct analogy to the reference situation in which the user is provided with or directed to specific data. Automated question-answering systems may be considered an accomplished fact, if one is dealing with highly structured data and if the questions asked can be confined to a simple and prescribed format. On the other hand, the answering of "free language" inquiries against a file containing text is much more difficult, particularly if one expects to receive a well-formulated answer. Even today, however, question-answering systems could prove to be valuable to reference librarians (rather than users). They are cognizant of the file and could be trained to use acceptable question formats. The difficult problem is in deciding what kinds of reference materials would be worth the cost and effort to store and query in this fashion.

Although completely automated question-answering is many years away, we are very likely to see, in the next several years, some level of question-answering capability in a number of reference facilities, particularly large ones with special missions (e.g., intelligence) or those that are part of a network and can share not only computer costs but reference material.

3.2.3.5 Computer-Aided Instruction

Computer-aided instruction (CAI) techniques, originally developed in an educational context, are now being seen as having a broader applicability. They offer considerable promise to libraries and information centers, both in the training of new library personnel and in providing service to users. The addition of an instructional element to an automated system--or to conventional systems, for that matter--can help library patrons learn how to use the particular library's resources or how to conduct some kinds of reference searches. The advanced study carrels being developed by some colleges, as part of the "library college" concept, may be the forerunners of new self-help ideas.

CAI techniques are not yet widely applicable in libraries because computers themselves are not widely used; too, no instructional materials have been prepared, either for the library staff or for users. With the increasing use of computers in libraries, however, and with the rapid progress being made in CAI, we are likely to see within a few years a number of CAI-type programs developed in connection with most operational programs for support to technical processes in libraries.

3.3 RELATED EQUIPMENT AND MATERIALS TECHNOLOGY

Another group of technologies that is particularly important for libraries includes microform technology, reprography, advanced publication techniques, physical handling and storage devices, and information transmission facilities.

Microfilm--previously considered valuable for space-saving and materials preservation--is seeing increasing use as a medium of communications, as the Federal Government and others begin to view libraries as distributors of information, rather than merely circulators. Inexpensive (under $100) microform readers that could be installed in one's office are currently available, and during the next five to ten years one may expect to see a number of efforts to establish large-size microfiche libraries that provide their users with either fiche or hard copy. As an example of the cost savings in microfilming, a $3.00 hardbound document can, when put on microfiche, be sold for only 65¢. We may expect to see many significant improvements in microform technology during the next ten years. This will include stable color microfilm, more sophisticated microform-handling equipment, and equipment for direct information transfer between microimage and computer subsystems.

Ultramicroform technology is now being developed that uses reductions of 150 or 200 to 1, rather than the usual ratio of 19 to 1, putting much more information on a single sheet. This ultrareduction allows for very inexpensive reproduction for a great number of copies, and has led to a proposal to create a thousand libraries of one million books in ultramicroform.

Reprography--reproduction by printing or copying--is of vital concern to libraries. With improvement of copying techniques, copying is competitive with offset printing techniques in cost and quality. Present reprographic techniques are efficient, rapid, inexpensive, and produce high quality, though costs and techniques vary widely (see Appendix C).

In the next few years, it is clear that the cost of copying will continue to drop, that offset printing will improve in quality, and that fiche reader-printers will improve in quality and cost less. There will also be increasing use of color. Electrostatic printers will use fiche as the source document, and progress will also be seen in printing from optical storage devices, magnetic tape or holographic devices, and ultramicrofiche. Graphic material will also see an increasing amount of production under computer control.

The advent of photocomposition--computer-controlled preparation of reproduction masters with electro-optical techniques--is very important for the library. It provides a means for some libraries to abandon card catalogs in favor of book-form catalogs, up-to-date versions of which could be printed in multiple copies to be available in several locations in the library. Quite apart from the printing aspects of photocomposition, the availability of library materials--text or catalog-type information--in machine-readable form provides an opportunity to explore other computer applications economically.

With respect to physical handling and storage, it seems clear that printed materials will continue to be the primary carriers to be dealt with for some years, and that few libraries will be able to use electronic means exclusively to manage their information. The carriers will have to be stored and handled by humans, aided, in some instances, by mechanical devices. There are some promising materials-handling devices—conveyors, tubes, containers, lifters, stackers, etc.—some of which can be useful in future systems where materials-handling is largely computer controlled. Most of these devices appear too expensive, at present, for widespread use.

Microfilm, magnetic tape, and magnetic discs pose less of a storage problem than books, though more sophisticated microfilm-handling devices will be needed, especially to support rapid and direct transfer between microimage and computer subsystems.

Transmission of materials is becoming an increasingly important area of interest to libraries, particularly in relation to possible network operations. The options include the U.S. mail, or a variety of electronic means such as television or facsimile transmission. The controlling factors in the selection of the transmitting and receiving equipment include the material to be transmitted, the quality of transmission desired, the available interconnections between transmitting and receiving equipment, and the cost of the interconnections. Current interconnecting links are standard telephone circuits, private telephone voice lines, video circuits, and microwave relay.

Of the several means for the transmission of materials, mail is still the most practical. Fiche have the lowest mailing rates per page (five fiche for 5¢, in contrast with books, at about 10¢ apiece). Video equipment—though it too provides low per-page costs, requires a high capital investment.

Efforts are underway to create working systems that employ advanced communications technology to support retrieval of material from a central store, transmitting it to a different place, and viewing it there. In such systems libraries would have remote consoles with video displays; there would be video communication links between local and regional libraries. Thus, any document within the region could be viewed from any place in the region.

In general, it is expected that both the accuracy and the data-transmission rates of various kinds of telecommunications equipment will increase in the near future (25). Communications satellites, which are currently in a development and testing phase, can also be expected to have some potential as a medium for transferring documentary information. What is not yet clear is whether there will be sufficient integration of the various kinds of transmission media and networks to serve the purposes of a more highly integrated library network.

In the next few years, communication among libraries may get a big boost from developments now underway in laser technology. The advent of laser technology promises a tremendous increase in what has been thought of as an already overcrowded communication capacity. Laser beams provide a wireless straight cable, on which it seems possible to impose signals. These signals can be carried along the surface of the earth or by repeat transmission from satellites. Though the results of laser research have been exciting and promising, the work is still experimental, and the techniques are not yet useful for libraries.

The other aspect of laser technology that may be important to the library of the future is holography, which has several possible uses in libraries, e.g., for storing multiple images on one photographic plate, or for storing color pictures of three-dimensional objects. This, too, is a technique whose perfection is still far in the future.

4. CURRENT APPLICATIONS AND TRENDS

4.1 INTRODUCTION

According to a recent survey (35), 1130 of the approximately 24,000 libraries in the United States either have, or plan to have within two years, some aspect of their operations performed by data processing equipment. Of this number, only 638 actually have some operational mechanized process; the others only had plans for mechanization. The majority of the 1130 were libraries having over 50,000 volumes.

Figure 4, based on figures from the survey, gives some rough indications of how data processing is being applied. All of the major library functions are drawing attention, although the emphasis is primarily on functions related to technical processes requirements. For libraries that are currently using data processing equipment, the function that has received the most attention (209 libraries) is probably that of serials management. The accounting function of the acquisitions process is also very popular, and logically so, since libraries are typically part of larger organizations whose functions in the accounting area may have been automated for some time. For other acquisitions functions, such as the production of purchase orders and accessions lists, the majority of libraries presently using data processing equipment for these functions use electric accounting machinery, rather than electronic computers.

Circulation control is also a popular mechanized function, and 165 institutions are using data processing equipment for circulation control. Data processing equipment is also being used for the reference function, i.e., document retrieval; this was found in 131 installations, 76 of which were special libraries in industrial organizations. No public libraries, and only 18 colleges and universities, were undertaking this type of activity.

The following sections briefly describe major operations within libraries and review current applications of technology to these operations. Since specific procedures vary widely, even within libraries of the same size and type, the operational procedures described must be understood to be typical ones.

Professional librarians and others who are already familiar with library operations may wish to skip the "Description" section for each function and read only the "Applications of Technology" sections.

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[4] While there is some question whether the figures reported in the survey are entirely accurate, there can be little doubt that only a small percentage of the libraries in the country are actually using or working toward data processing technology.

Function	Total
Acquisitions Functions*	
Acquisitions	102
Accessions lists	170
Accounting	235**
Cataloging Functions	
Catalog cards	101
Book-form catalogs	125
KWIC indexes	135
Circulation Control	165
Serials Control	209
Union Lists	133
Reference Functions	131

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*It is not possible to add sub-groups together, since some libraries are represented in each, e.g., a library may produce all three: catalog cards, book catalogs, and KWIC indexes.

**An unknown number of libraries have payroll operations included in this function.

Figure 4. Number of Libraries (35,69) in the U.S. Using Some Form of Data Processing Equipment, as of October 1966 (Selected Functions)

4.2 ACQUISITIONS FUNCTION

4.2.1 Description

A logical starting point in discussing library operations is that of acquisitions, since materials must be selected and acquired before they can be used. The book trade is very specialized, and typical library practice is to carry out the purchasing functions within a specialized library department, rather than to use a purchasing department of the parent organization.

Contemporary U. S. publications from the larger trade and textbook publishers can be obtained anywhere in the country with a minimum of difficulty. The only problems likely to be encountered by a library dealing solely with such materials lie within the strictly clerical operations of handling the paperwork involved in the ordering process, and service from some publishers is likely to be slow. Sometimes legal requirements of the parent organization add to the delay.

Research libraries, academic libraries, and some public and special libraries purchase materials in foreign languages, and/or printed in every country of the world.

The acquisitions process is complicated by the fact that not all countries have a well-established book trade. For this reason, the Library of Congress, under recent legislation expanding the importation of foreign materials into the country, has found it necessary to establish and man field stations in certain countries.

Some libraries have additional problems with out-of-print materials--items that are rare, old, fragile, etc., and in exotic languages. Libraries are forced frequently to deal with particular vendors whose special requirements require some kind of special paperwork, or prepayment, which, under the rules of the particular library, may be very difficult to make and cause a great deal of extra effort. All of these factors have a bearing on the way that technology and automation may or may not be applicable.

Other types of acquisitions present special problems. For example, some libraries receive Federal, state, or local government publications automatically as designated depositories, while some acquire foreign government documents or the voluminous publications of the United Nations and its agencies. Depository libraries must claim materials that are due them, but are not received, for one reason or another, and must maintain records, even though there is no financial matter at stake.

Despite recent improvements in the distribution of government documents, there are still large numbers of documents produced by various Federal agencies that do not find their way into the normal distribution channels through the U. S. Government Printing Office. For many of these documents it is not possible to achieve regular distribution and receipt by a particular library. Thus, a great deal of effort must be expended to discover and acquire such materials.

The acquisitions department also handles non-book materials, for example, maps, phonograph records, tapes, slides, motion pictures, and microform versions of various standard publications. These all have special problems of acquisition.

A specialized aspect of acquisitions is the gift and exchange operations carried on by many libraries. Many gifts come to the libraries in poor physical condition and without a listing of the items included. To check such materials in order to determine which items to retain is very time-consuming, and unless the gift is a particularly valuable one, it is probably more costly to the library, in the long run, to accept such materials than it would be to buy the relatively few items that it really wants.

The most critical problem connected with receiving large gift collections without a catalog is that the library must invest the time to produce a catalog of the collection if it wishes to derive any benefit from the gift. This is both a clerical and a professional operation, and is discussed in more detail under "Cataloging Functions" (Section 4.3).

Exchange is perhaps more peculiar to academic or certain governmental libraries than it is to most public or special libraries. Agreements for the exchange of materials free of charge conserve the book funds of the institution and, more importantly, they are the only way that some materials can be obtained at all from some foreign countries. For example, several U. S. academic institutions have been able to establish exchange agreements with academic institutions in Red China, and are thus able to acquire materials that cannot be easily obtained in any other manner. The same is true for the Soviet Union and certain other nations. Such agreements, however, require diplomacy on the part of the exchange librarian, and maintenance of accurate and timely records of the exchanges, even though the volume of material received by exchange is generally small. There are a few libraries in the country (such as the Library of Congress) that have a very large exchange program.

Certain libraries also use "blanket orders," a scheme for ordering, on approval, all materials published on a particular subject. Where the volume of materials received is large, these agreements with book vendors or publishers may involve considerable record keeping, as well as very complicated financial arrangements with accounting departments; but the resulting speed of delivery and ease of selection are worth the additional paperwork, if any.

The final area of acquisitions to be discussed here is that of continuations, which can be defined as all materials outside of the one-time orders that bring in a complete item. They include serials, series, terminal sets, works issued in fascicules, anything issued in some numbered or ordered sequence, and other "extended procurement." Regularity of issue is not a factor.

Serials are a form of continuation that are issued more or less periodically without a definite cutoff date. This contrasts with monographic series, which have no definite ending point, but which do have a predictable end (e.g., the collected works of a given author, now deceased).

Serials have a unique aspect that causes them to be handled, in most libraries, as a separate operation. For a given serial title, an order once placed will result in the receipt of issues of that serial for years into the future, for most serials are published with the expectation that they will continue indefinitely.

The operational problem with continuations of any sort is not so much the placing of the original order but the maintenance of the records necessary to keep track of the continuing delivery of the items. Such continuations may extend over many years and over the employment period of several individuals. Serials are discussed in more detail in Section 3.6, "Serials Management Functions."

A useful starting point for describing the operation of a typical acquisitions section is the one at which requests are received. The library first searches to see whether the material is already owned by the library, has been ordered, or is being processed in the cataloging section. After this preliminary check is made, if the library decides to order the material, enough additional information about the item to establish a correct entry is sought, and an order is prepared and sent to a vendor or to the publisher. A record is kept of this order, notices are sent to any interested parties or departments, and a particular departmental book fund may be charged. When the item is received, copies of the order are pulled from the outstanding order file and other files, and the book then moves into the cataloging process. Part of the acquisitions function may be the ordering of Library of Congress cards. Sometimes that function is carried out by the cataloging section. They receive a copy of the purchase order and, in turn, send a card order to the Library of Congress or to some other card service.

4.2.2 Applications of Technology

Certain aspects of the acquisitions process lend themselves particularly well to automation or to the use of other forms of technology. For example, the production of orders to vendors is very similar to the production of orders in any purchasing activity, and computers can do this very readily. The maintenance of purchasing records and the charging of funds against particular budgets are other activities that have been successfully mechanized in the business world and that are being mechanized in some libraries.

As indicated in Figure 1, there were 102 libraries actually using some form of data processing in their acquisitions process, as of October 1966. A recent survey (35) reported that 419 institutions had plans for use of data processing in acquisitions, and that of these 419, 139 planned to begin such use by the end of 1968. These projects in acquisitions are endeavoring to do one or more of the following: (1) order library materials; (2) maintain financial records; (3) collect and record statistics on the order process; and (4) print lists in various arrangements of materials in process.

Financial reports may be arranged in a variety of ways, for example, on the basis of materials ordered, by fund, by subject categories that are not represented by funds, by accumulation of items ordered from particular vendors, by standing orders, etc. It is sometimes useful to know how many items have been ordered from particular vendors over a period of time, the amounts spent with these vendors, the discounts received, how rapidly particular vendors have responded to orders over a period of time, total number of orders placed within a particular calendar period, etc.

Lists of materials in process are useful for a number of purposes, especially when items on order can be entered and located in a variety of ways. The typical method in the past has been to enter under a selected entry in an order file with no cross-references. This makes it exceedingly difficult, if one does not have precise information, to discover materials actually on order. Using lists that can be arranged in various manners, on-order and in-process materials can be controlled throughout the time from receipt of request within the division, mailing of the order to a vendor, receipt of the order, and cataloging, to the time they are ready for use.

While there are some automated acquisitions systems operating, we know of none that includes all of the possible products or operations listed above. A few institutions have either planned or are implementing systems that are as "complete" in concept as one could currently hope for. References 27, 76, and 107 describe several of the limited number of complete systems; none of these is operational yet.

Aside from the use of data processing equipment, and in some cases the use of related accounting machinery or bookkeeping machines, libraries have done little experimentation with available technologies. Very few libraries utilize materials-handling equipment, such as dumb waiters, conveyor belts, etc., in the acquisitions area. Some libraries have experimented with communications devices such as Deskfax, direct photocopying devices such as the Photoclerk, edge-notched cards, and automatic typewriters. In general, though the area of materials-handling and the use of photography in processing have not been given as much attention as "automation." While photography may not hold as much long-range potential, either for the reduction of costs or improvement of output, it is an area that is not receiving the research and development attention it deserves.

Since the acquisitions procedure seems to be so similar in libraries of comparable size and type, a number of cooperative projects have been started to develop processing centers for groups of libraries. Such cooperative processing centers have been in operation for some time in northern California, Alabama, Michigan, Ohio, North Carolina, and Indiana; and centers are being studied in Colorado, New York State, Ohio, and other places. These centers will perform all the typical functions--preparation of orders, selection of vendors, checking-in of materials, cataloging, etc., and finally delivering the items, ready for the shelf, to the participating libraries. It is apparent, of course, that such centers can operate in the same (manual) way that most library acquisitions departments have operated for many years. Yet, the use of data processing equipment makes the cooperative processing center a much more attractive proposition.

The potential savings of cooperative or centralized processing centers have not always been realized. For example, a recent study of a centralized processing center in Illinois showed that although personnel were relieved of the processing task and work-space pressure was relieved in some of the participating libraries, the actual cost of processing through the center was, for some of the participants, greater than costs of doing the work themselves (58).

Reported costs of existing cooperative centers vary widely. The reported costs are difficult to compare with previous costs, since almost no one has obtained cost figures during a previous operational period and then studied the same operation after the processing center has been established. In addition, the services provided may differ from one center to another. For example, some centers use very simplified cataloging, whereas the center in Illinois mentioned above used a cataloging code that resulted in better quality but more expensive cataloging than had previously been the case in the individual libraries.

The Association of Research Libraries has been studying the possibilities of cooperation for many years. Under their Farmington Plan, individual institutions undertake the purchase of foreign publications from a certain area or on a certain topic, and then serve as a national center for such materials, thus relieving other institutions from purchasing in that particular field. Recent activity at the Library of Congress under Title II of the Higher Education Act has also served to further the cause of cooperative purchasing and processing. These cooperative activities could be the beginnings of true networks.

It is difficult to predict with accuracy the extent to which the trend toward centralized and cooperative processing can be carried. The cooperative processing center or the centralized purchasing center tends to limit free enterprise within the book trade. It is conceivable that a cooperative or centralized purchasing activity could be large enough to dispense with the services of booksellers at the retail level or even the wholesale level, and deal directly with publishers in all cases. If extended over a large enough geographical area, this could adversely affect the fortunes of a number of booksellers. Also, there are numerous legal barriers in the way of widespread cooperative purchasing and processing, if the members are located in different political jurisdictions (i.e., different counties, states, or countries) or if some members are publicly supported and others are privately supported.

4.3 CATALOGING FUNCTIONS

4.3.1 Description

Libraries have developed highly complex systems to categorize the materials they acquire to make them accessible to the library's clientele on the basis of subject matter, author, and title of the work. In the "cataloging and classification" process, numerous categorizing schemes are used, the most widely used being the Dewey Decimal Classification and the Library of Congress Classification systems. Alphabetically arranged subject headings are also used, as well as the occasionally used newer techniques such as descriptors, key-word-in-context, etc.

The amount of effort expended in the description of the item varies from library to library; some libraries expend a great deal of effort on a precise physical description of library materials, as well as on their subject categorization. Apart from the physical description of the item, there is the matter of assigning an "entry" to the material. Because of the nature of the so-called "dictionary catalog" (on small cards), the concept of main entry has been important in cataloging work. Selecting the main entry, putting it into proper form, and selecting appropriate subject headings and classification numbers or coordinate indexing terms are time-consuming tasks.

In most libraries, the descriptive cataloging and the subject classification are done by the same people; in others this work is separated; in still others, catalog sections are operated in conjunction with the acquisitions activities. In many libraries, the catalogers use Library of Congress printed catalogs for guidance, but they also maintain their own "authority" files, which give proper forms of names, series titles that are used or not used in that particular library's catalogs, proper forms of subject headings, etc. Libraries typically maintain special catalogs known as "shelf lists," which are maintained in the same order as the books are shelved within the library. It is an inventory record primarily, but can sometimes be used as a "classed catalog," since the file is usually organized by the classification scheme in use in the library

The end result of operations in a cataloging section is a series of codes assigned to a given item, and a description of the item. Together these constitute the cataloging entry for that item. Typical library practice in the past has consisted of making catalog records on $7\frac{1}{2} \times 12\frac{1}{2}$ cm. cards. Printed cards may be purchased from other organizations, e.g., the H. W. Wilson Co. or the Library of Congress, or produced at the local library.

A particularly nagging problem for many libraries is that of "arrearage," which is the general term given to the large quantities of uncataloged materials so frequently found in catalog departments. Libraries often acquire large collections in one transaction, completely overloading the catalogers. More and more libraries have these unprocessed backlogs, for they are reluctant to pass up any chance to acquire materials that may, later, be unavailable or available only at greatly increased prices.

4.3.2 Applications of Technology

The most popular application of technology to the cataloging process has been to reproduce catalog cards. Although the cost of purchasing cards from the Library of Congress is relatively low, some libraries prefer to produce all of their own cards using copy provided by the Library of Congress proof-sheets (proof copy of new catalog cards) or Library of Congress printed catalogs. These libraries are sometimes able to reduce the costs below that of cards obtained from the Library of Congress. Techniques sometimes involve photocopying, but a few libraries rekeyboard the item on paper tape for production of the necessary cards by automatic typewriter or computer. "Book catalogs" are catalogs in the form of a book (or codex) rather than individual cards. This form of catalog, frequently used many years ago but abandoned in favor of the card catalog, is returning to favor. With the new technology, some of the disadvantages of the early book catalogs are no longer serious. The major objection to book catalogs of the past was that the cost of keeping them up to date was prohibitive. With present-day equipment, especially computer-controlled typesetting or computer printing in upper and lower case letters, the cost of reprinting catalogs on a regular basis has become much more competitive with the cost of maintaining large, complex card catalogs. A further advantage of the printed book catalog is that it can be produced in multiple copies for use at a large number of service points, including distant ones.

A few libraries are now producing catalogs by computer in a book form, with holdings arranged by author, title, and subject. These are produced on a regular basis and updated as necessary.[5] Some libraries are producing (or planning) cumulative monthly lists of currently cataloged items, authority lists of subject headings, and lists of currently cataloged items arranged by the special interests of the library or its clientele. In addition, some projects are seeking to gather by-product statistics for library administration, e.g., work-performance records by cataloger.

The combination of interlibrary cooperation and new technology offers great potential for the reduction of costs and wasteful duplication of effort in cataloging. There are already a number of smaller cooperative processing centers that combine acquisition and cataloging functions, presumably with economic advantage to the participating libraries. The Library of Congress also continues to play an increasingly important role in cataloging. Because LC catalogs a significant percentage of books acquired by libraries in the United States, it has been--on economic considerations alone--an effective agency for the reduction of cataloging effort by a large number of libraries in the country. In fiscal 1966, over 72 million cards were distributed by its Card Division. With its expanded role in procuring materials abroad and cataloging them more promptly, even greater savings are possible. The MARC Project, which is a prototype of a national network for the distribution of machine-readable catalog data, has great potential in this respect (118).

There are other aspects of the cataloging process that could benefit either by centralization or mechanization. A cooperative, centralized operation could consolidate "authority files" or even "official catalogs," and the consolidated authority file could become a part of a union catalog for the participating libraries.

Aspects of technology other than data processing are also beginning to contribute to the cataloging process. There has been some interest in camera equipment that a cataloger could use to copy data from available LC printed catalogs or other national bibliographic records. Only recently has a camera been introduced (by the Polaroid Company) that was especially intended for use by catalogers. Whether it is satisfactory is not yet known.[6] Materials-handling equipment also has potential, although this area has not been exploited to any large extent. A few libraries have installed large rotary shelves to offer better access to large reference sets, such as the Library of Congress printed catalogs. Some forms of compact storage have also been developed, but relatively little study has been made of possible improvements in materials handling to support the cataloging process.

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[5] One of the unresolved problems connected with the computer production of book catalogs is the filing sequence of entries within a particular catalog. Existing filing rules demand a high level of human intelligence for their accomplishment. The rules must be modified to some extent in order that a computer can follow them. There is not yet unanimous agreement within the library community just what modifications should be made.

Some equipment has been developed to aid in the placement of call numbers, letters, and numbers on book spines. This is a relatively unglamorous part of processing, but one that is necessary in every library. The tool developed for this purpose by the American Library Association's Library Technology Program (LTP) works reasonably well, and saves some amount of time and money, but it will not work with the most modern typewriters.

A few libraries have considered certain aspects of purchasing, receiving, and cataloging as a single process, and are attempting to establish systems that capture the bibliographic information concerning each item ordered, at the time it is ordered. This abolishes the need for re-keyboarding time and time again, throughout the entire system. This is a promising approach, especially for handling currently published material, for which full identifying information is available. If consideration is limited to contemporary publication in English, by far the bulk of the acquisitions in libraries of the United States, there is no question that this goal can be achieved. If there were library networks, interconnected by communication links, keyboarding could be further reduced by storing the bibliographic information for each item in a machine-readable store. Any other library could then call out the complete record from the store by inputting only a small portion, sufficient to identify the entry. It might be possible to use only the Library of Congress catalog card number to retrieve the complete bibliographic record.

There are at least two current attempts to implement some of these ideas. The MARC Project has already been mentioned. Another major effort is in New York State, where a network is being planned for a medical library system (84). It is anticipated that there will be a centralized technical processes center for the entire New York State University system, with communication lines linking all of the libraries.

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[6] Other efforts have recently been announced for development of a "Bibliographer's Camera." The Council on Library Resources is sponsoring this work.

In the near future, the use of computers to produce book catalogs will undoubtedly become more widespread, particularly with the advent of devices that can transform computer output directly onto film. The Chemical Abstracts Service, which is preparing to print Chemical Abstracts entirely from computer output in a few years, has a device that will take computer output (using a character set of 1452 separate characters) and place it on film, from which it can then be made into an offset printing plate. The same process could be used to produce library catalogs, either union or individual. In addition, microfilmed catalogs produced in this fashion could readily be copied and distributed in cartridge form, so that libraries could have union catalogs for their patrons at many points at a relatively low cost.

Communications technology could also be important in relation to uses of the catalog. One idea, which few libraries seem to have considered, is to establish direct communication from the public catalog area to the catalog department, to help reference personnel or patrons obtain assistance in the use of the catalog. Communications technology may also prove very useful in relation to storage facilities. There have been some efforts to establish such facilities for a group of libraries in an area of low real-estate cost. The use of "slow-scan" TV to send tables of contents, etc., to distant patrons over ordinary telephone lines, apparently not yet studied, is worth investigating.

The problems of arrearage might be eased by better exploitation of data processing technology and, possibly, materials handling technology. Various schemes have been devised by some large academic libraries to produce brief descriptions of these materials and then to store them away. None seem to have followed the lead of some special libraries, which have used data processing to produce permuted indexes to their arrearages. The use of compact shelving of various types might enable libraries to handle their arrearages more effectively. Most libraries have not planned for such shelving, however, and its installation and use may be considered too expensive.

4.4 CIRCULATION FUNCTIONS

4.4.1 Description

Most libraries employ some kind of circulation control system to keep track of the materials borrowed from the library. Such systems vary from the very simple to the extremely complex, in accordance with the type and importance of information needed. In England, some libraries give their patrons a number of tokens, which are exchanged, one by one, for books that they take from the library. When a book is returned, the patron receives a token back, but no record whatsoever is kept to show what book the patron has or who has what book. The only apparent use of the tokens is to restrict the number of materials that a patron can have out from the library at one time. Libraries in the United States usually want much more information and control.

It is in the area of circulation that we find perhaps the greatest operational differences among the three general types of libraries identified earlier. Although most public libraries do seem to have some sort of limit on the number of books that patrons may take out at one time, they generally attempt to maintain controls only with respect to the date of return. Thus, there is usually no way to discover what materials are out to what particular borrower. Some academic libraries have special circulation problems, in that they have special collections of materials that are loaned for very short periods of time. These items may carry rather high fines for even short periods of overdue use, and record keeping is a large operational problem for these libraries. Academic libraries, in general, feel it necessary to be able to determine who has a particular item when it is out and to control the length of time materials are out. Special libraries generally try to keep some sort of inventory of materials out to each borrower but they tend to be especially liberal regarding their loan periods. Some special libraries also need to maintain control of security classified documents, not a typical problem in either academic or public libraries. For such documents, the concept of "accountability" is paramount.

Another, rather specialized, aspect of circulation control involves non-book materials, which have their own unique problems. For example, the circulation of motion picture film involves not only circulation control, but "booking in advance." This requires specialized records, as well as efficient routing and distribution. Other materials loaned by libraries also have specialized requirements. Phonograph records and audio tapes, for example, require special handling not typically afforded book material. Circulation of periodicals for limited periods and their inspection after each use present additional problems that seemingly demand human attention and have relatively little potential for mechanization. However, technology might have some answers if the proper efforts were made to discover them.

In recent years, circulation control has received much attention, no doubt because many libraries have acute problems in this area.[7] Academic libraries, especially, have had their circulation systems very much in the public eye. Some have had operating problems that cause long queues to build up at charge-out points. (Waits of up to an hour for service are reported in the literature.) Such conditions cause considerable dissatisfaction among the patrons. Thus, a number of them have selected circulation control as a first step toward automation.[8]

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[7] A number of studies have been made of circulation control systems within recent years, under the sponsorship of the Library Technology Project of the American Library Association. While these studies have been, in general, carefully planned and have produced some useful results, there has not been complete agreement on the validity of the techniques used in the studies or their results. The benefits of management information have been completely overlooked as a desirable byproduct of a circulation system, and are not even considered in the assessment of costs. At the present time, the effort seems to be to use data collection equipment solely for the purpose of solving operational problems.

4.4.2 Applications of Technology

According to the Creative Research Service Survey (23), about 165 libraries are now using data processing technology to support the circulation control function. Current projects in this area seek to do the following: produce lists of materials actually in use and identify their location; produce lists of materials in use by individual borrower; produce overdue notices automatically; collect circulation statistics by borrower category, subject category, or any other particular category of interest to the library. Subfunctions of some of the foregoing processes are those of producing lists of materials having one or more requests outstanding ("holds and recalls"), so that management action could be taken; producing cumulative records of the use of particular items, with automatic notification of materials used so frequently that they are likely to need rebinding; and producing annual listings of materials out on long-term loans to certain categories of borrowers.

Some public libraries have had very comprehensive circulation control systems for years. Perhaps the most outstanding is the Montclair (New Jersey) Public Library, which uses custom-built IBM equipment to keep track of the records by item, by borrower, and by due date. Only recently has comparable equipment become generally available. A few academic libraries now have systems that permit an inventory of materials out to a particular borrower. Others can run an inventory for all materials out on long-term loans, but cannot answer directly the question, "What materials are loaned to the borrower, Mr. Jones?" All of the operating automatic or semiautomatic systems work on a "batch" basis.[9] The concept of batch processing implies that data are

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[8] A case in point is Johns Hopkins University, which has devised what seems to be a fairly expensive system of circulation control, the design criteria for which had as a prime requisite the ease and speed of moving through the circulation control point from the patron's viewpoint.

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[9] There are a fair number of systems, more or less similar in operation, that use data collection equipment: for example, at University of Southern Illinois, University of Missouri, Washington University, Santa Clara Public Library, etc.

fed to the computer all at one time, rather than being fed to it from time to time, "on line." A few institutions are beginning to work towards the development of actual on-line operations that will tie a circulation control system directly into a computer at all times. None of these is yet operational.

Using data collection equipment tied directly into a computer, libraries could handle one- or two-hour loans; this would demand considerable random-access memory, but the value of the use statistics that could not be gathered any other way might well justify the added cost. Within libraries of a size large enough to have branch operations, a limited network arrangement could be useful for circulation control. All the branches could participate in the one common system by the use of remote data collection devices, thus placing in one central computer record the total circulation file. This would enable librarians to ascertain the current availability of particular titles within the system, much as the airlines check for available seats. Public librarians have not felt that this was a necessary part of their service in the past, but they might well do so if the system permitted it.

Circulation control could also be operated on a network basis within a region, it would seem, quite efficiently. Many libraries banded together could afford equipment that no individual library, or even several libraries, could afford. This might allow effective on-line operations at a reasonable cost. Efforts along these lines will undoubtedly begin to take place; there is already some research under way along these lines by private organizations.

The concept of cost/effectiveness has usually been absent from the discussion of circulation control systems, especially in connection with existing manual systems. Cost/effectiveness is not the same as cost, a distinction often ignored. An all-too-common approach to circulation control considers only the lowest possible cost of the operation to the library. The idea that circulation statistics can also provide important management information over a period of time seems not to have taken hold yet, for few public libraries have sought to devise circulation systems that would enable them to collect such management data at a reasonable cost. Future efforts undoubtedly will begin to see more attention paid to this. Cost to the user is also a topic which is beginning to attract attention.

After materials are used, they must be reshelved or replaced by the circulation section. Technology has had as little effect in this operation as it has had in the similar operation of "paging" books in libraries that do not allow their patrons access into the stacks.[10] While some use has been made of pneumatic tubes to transmit call slips and even books, these are point-to-point operations, and materials must be taken off shelves and replaced by hand.

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[10] At the Technological University Library in Delft, Holland, a special telephone system is used to transmit the stack location of the desired item to a "page" in the proper area of the stacks. The page picks up the book (or responds that the book is not there) and places it on a specially designed spiral chute, which delivers the book to a pickup point.

Some interesting suggestions for materials handling have been made, for example (64), that the principle of the linotype could be used to position, deliver, and replace a book in a particular place within a collection. Following this suggestion, a staff member of the Council on Library Resources has outlined a system using plastic boxes to contain and transport books in and out of the stacks (70). It appears that no one in the library world--even including the Council itself--has taken such suggestions seriously enough to initiate experimental work.

Remington-Rand has recently announced a system which is, in effect, an automatic stack and is intended primarily for automatic handling for storage and retrieval of materials kept in file folders. The manufacturer claims that the system will handle materials in codex form. The economics for library operations of this system are unknown, since only a prototype of the equipment exists at the present time. (This equipment is also discussed in Appendix C, "Related Equipment and Materials Technology.")

4.5 REFERENCE AND REFERRAL FUNCTIONS

4.5.1 Description

Reference and referral is another aspect of the public service side of all libraries. It includes helping the patrons find and identify materials of interest, making requests to other libraries, if necessary, and helping patrons in the use of reference tools. Reference work also includes the production of specialized bibliographies. Public libraries also have a "reader's advisory" function. This is generally not considered important or necessary in special libraries or academic institutions, where the patrons are students, faculty, or research personnel.

Part of the help given patrons involves interpretation of the library's catalog. Thus, card catalogs are typically placed in a public area where they are handy to the reference and circulation sections, even though this may make them very unhandy for personnel in the technical processes area. In some libraries greater use of library catalogs or library reference materials is made by the staff of the library itself rather than by patrons. However, the library's orientation toward service to its patrons usually dictates a location convenient for their use.

Some part of the public services section of the library, usually the reference department, will handle requests to other libraries for materials the library does not have. In the area of interlibrary loans, library cooperation has been truly remarkable. All libraries, public and private, can obtain interlibrary loans, not only throughout the United States but overseas. Some of the larger libraries have used communication devices such as the teletype to handle their interlibrary loan requests. The Library of Congress with its National Union Catalog[11] serves as a focal point for the activity in this country, although certain academic libraries may have local cooperative agreements within a region, and therefore make their requests within that local group before using the Library of Congress resources. For these reference and referral functions of interlibrary loans, union catalogs are almost indispensable. Without them, interlibrary loan activity would require circularizing a large number of libraries until one located a particular library that had the desired material.

Reference work frequently involves making copies of library materials for patrons. Sometimes these are copies of tables from reference works that cannot be removed from the library. Since circulation of periodicals is frequently restricted, there is also heavy traffic in photocopies of articles. There is also frequent demand for microform materials, especially the widely used roll microfilm in 35mm format.

4.5.2 Applications of Technology

Very little in the way of technology, with the exception of communication devices, can presently be found in most reference departments. A very few libraries have automated their information and document retrieval functions. In general, these systems work as follows. A variety of guides or indexes to document holdings is available, from which users select key words, subject headings, uniterms, etc., as search keys. The search produces lists of document numbers, sometimes including abstracts of material matching the subject criteria input.

There are also some primitive automated data retrieval functions along the same lines, generally using some type of subject categorization for the construction of search requests. Most data retrieval systems can do only such simple things as producing a series of sentences that contain some prescribed or desired words, or a listing of physical data that meet certain criteria. Most of the automated data retrieval systems are in information centers; almost no libraries have automated data retrieval functions.

Project Intrex at MIT combines some aspects of document and data retrieval within a library function. Intrex (information transfer experiments) is a program of research experimentation directed toward the functional design of new library services that might become operational at MIT and elsewhere by 1970. The research program is addressed mainly to the broad problem of access--in particular, access to bibliographic material, documents, and data banks. The four areas of activity encompassed by the core program of Project Intrex are: an augmented catalog (computer stored), full-text access at stations that are remote from the store, fact retrieval, and network integration (96).

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[11] The National Union Catalog at the Library of Congress was established with the aim of recording locations throughout the country of primarily scholarly material.

Some current mechanization projects have implications for reference. For example, where libraries have mechanized their catalog records, using computers either to print catalog cards or to produce book-form catalogs, there is also the inherent capability to produce specialized listings of materials in a particular area. The computer can be used to retrieve references and tailor a bibliography specifically to the needs of the patron, with limits, for example, on date of publication, language of materials, and subject headings.

Some communication devices have been used in libraries for some time. The Electrowriter and other similar systems have been used to transmit handwritten requests from one point in a library to another, or from a branch library to another element of the system. Several recent projects, have explored the use of telefacsimile processes to transmit needed materials from one library to another. While the promise is great, so is the cost. Here again, libraries are making use of equipment and technology developed for other uses and not especially suited to library problems. For example, the typical facsimile process is not usable with bound materials, except through the use of the television camera. With the typical commercial television equipment and common carrier transmission systems, the cost for transmitting even a few pages is very great. No work has been done, so far as we are able to determine, with "slow-scan" TV processes[12] for library purposes. Lecture demonstrations have been held at several places in the country where materials used by the lecturer at the transmitting end were displayed on a screen at the receiving end. Such equipment is said to work over voicegrade lines and does not involve too great a transmission time. On the other hand, it produces only a display, not hard copy, at the receiving end.

Typical library equipment for using microforms is far from satisfactory for long-duration usage. For some reason, existing optical technology has not been exploited to the fullest. Microfilm equipment manufacturers seem to think that microfilm readers and other types of microform readers must always be "portable," and librarians have, apparently, accepted this position. Yet, such machines are usually placed in a particular location, used there, and rarely taken from that location, and could just as well be built-in. This would ease the normal restrictions on size and would allow the optical designer additional freedom to use long focal lengths to improve display on the screen. Existing standard optical techniques could be used to build a high-quality reader that would be comfortable for a patron to use over a long period of time, in a reasonably well-lighted area.

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[12] Some studies have been made with closed-circuit TV, but these were made some years ago prior to the advent of the slow-scan process. For ordinary TV use the costs are now too great because of bandwidth requirements.

Such equipment has not been built because the development cost seemed prohibitive without a guaranteed market. Not enough librarians have been actively concerned with utilization of microforms to demand the better products that could be made, and no efforts seem to be under way to improve the situation. Yet microforms will need to be used more extensively in libraries in the future. Large numbers of books printed over the past century are deteriorating, and some of these undoubtedly will be preserved only in microform. Most libraries that want them will be able to afford them only in microform. The possibility of large library collections (e.g., one million volumes) solely in microform is also very much on the horizon. The increasing amount of material available in microforms will undoubtedly help to accelerate efforts to improve the handling, storage, and use of microforms. (See Appendix C, Section 2.)

Some effort is being made to bring techniques of automated "information retrieval" to reference work. A few libraries are already contemplating the use of computer equipment to make their catalog records available on-line, and are also considering placing computer display consoles in locations for use by patrons. Reference librarians may well be "tied into" the circuit so that, if the patron's own searching of the library catalog is unsuccessful, he can call a reference librarian, who can interact with the patron and the computer to assist. Before this is an everyday occurrence, a great deal of experimentation must be carried on to determine what kind of retrieval system is required for such interaction, and what kind of preparation and training are required of both the librarian and the patron.

The development and use of statistics regarding reference service has always been a shaky affair in libraries, largely because reference activity is very complex and because the personnel involved with reference functions have not had adequate time to record all of the daily transactions. This area will undoubtedly receive attention in the future, as computers are called upon to interact with librarians and patrons. Such devices could allow the easy compilation of management information forms that could be very useful for library administration. For example, the use of statistics rapidly gathered from interlibrary loans and arranged for easy interpretation could enable the library administration to improve the library's collection systematically. Most libraries try to do this now, but without appropriate tools, it often must remain a pious hope rather than an actuality.

4.6 SERIALS MANAGEMENT FUNCTION

4.6.1 Description

Serials were described earlier, in the section on Acquisition, as one form of continuations. It is difficult to say what constitutes a serial in a given library; most libraries have their own definitions that they follow. For purposes of discussion, we will consider as serials anything listed in New Serial Titles or the Union List of Serials

Because they appear in such a wide variety of forms, and because of the difficulty of maintaining records concerning them, serials have frequently been handled by a completely separate operating division within libraries, especially in libraries of medium to large size. Smaller libraries do not usually have the wide variety of serials that the larger public, academic, and special libraries have.

Although the more esoteric, foreign language, scholarly journals cause great difficulties in handling serials records, it is the sheer volume of details necessary in maintaining serials that is the primary source of trouble. Also, serials have an additional problem that only infrequently is important in dealing with monographic works, namely binding. Periodicals have many separate, discrete parts that must be gathered together and placed in some sort of hard cover for preservation. Most libraries either replace their unbound journals with microforms or bind them, which adds an additional aspect of record keeping. Records must be kept of what is at the bindery; separate records are needed of what is bound and what is not, because these materials may be shelved in separate locations.

Large libraries with many branches have a tremendous record-keeping problem, since they try to record the exact items housed in any particular location. If an attempt is made to centralize such records manually, it can only be done economically in one place. Thus, branch locations may not have ready information on what materials may be in other branch locations.

As especially time- and manpower-consuming function is the claiming of serials which do not arrive on time, or at all. In order to carry on claiming, up-to-date information on serial receipts is necessary, because some serials, if not claimed promptly, will be out-of-print and unavailable. Claiming can be seen to be especially demanding of diligence and accurate records.

Union lists are another especially important aspect of serials management, since no library in the country has all of the journals ever published, even those of the United States. Every year, literally thousands of new journals--scientific, technical, and others throughout the world--are "born," and thousands "die," seemingly with a gradual net gain of live titles.

4.6.2 Applications of Technology

There is an unknown but **sizable** number of projects under way to convert serials records and record keeping to machine-readable forms so that they may be produced in a much more timely fashion. Some of the work on book catalogs has promise for serials management. For example, book catalogs, extended to include periodical and serial holdings and reproduced in multiple copies, have been successful in alleviating the problem of providing ready information to branch libraries on serials holdings. Once there has been a sizable conversion of serials information to machine-readable form, it should be considerably easier to create and maintain union lists of serials. The monumental compilation of the third edition of the Union List of Serials of Libraries in the United States and Canada is a case in point: This final edition took literally decades to complete.[13] If all the records had been machine readable and computer programs had been available to manipulate them, new editions could have been produced on a yearly basis.

Communication devices and data processing equipment offer tremendous potential for tying together the holdings of one library with that of another, within regions, and nationally. With the addition of the capability of transmitting facsimile copy through communication links, it becomes possible to consider centralizing, on a regional or even national scale, serial holdings of lesser-used materials. There have been efforts along these lines--without advanced technology--by libraries in the past, a prime example being that of the Center for Research Libraries, located in Chicago.

The question of cost/effectiveness becomes important in such considerations, and at the present, providing copies of journal articles for distant patrons is probably better carried out by common reproduction equipment and the U.S. mail, than by costly telefacsimile processes. Initial efforts are already under way, in certain regions of the country, to produce union lists of serial holdings for certain organizations having numerous branches,[14] and such efforts will undoubtedly accelerate in the near future. A most encouraging development is the recent beginning of a project at the Library of Congress to determine precisely what elements of information should be put into a machine-readable record for a serial title. This is the groundwork on which a national serial data project can be built, and that hopefully will be undertaken at the Library of Congress in the near future. Both this effort, and the recent known desire of the EDUCOM Network Task Force to convert the Union List of Serials to machine-readable form deserve greater support than they now have, since they offer tremendous potential for all libraries, not only in the United States, but worldwide.

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[13] The exact number of years involved is a matter of definition and is the subject of controversy.

[14] For example, State University of New York with its 58 branches.

The semivoluntary efforts of the American Society for Testing Materials (ASTM) to establish a uniform code for serial titles were noteworthy; ASTM offered to assign a standard code ("CODEN") to any serial title submitted to them in any field of knowledge. The Franklin Institute of Philadelphia has recently assumed responsibility for the CODEN effort. Standardization efforts of this kind, which help to establish codes for use in computer-based files, ought to have greater national and international support.

Despite several years of effort in the automation of serials records, relatively few institutions have operational systems, and those that exist do not perform all the necessary functions of serials management. Current projects undertake to produce the following types of records and control information: lists of currently received materials; cumulative lists of holdings, that is, materials actually in the library; claim reports for issues that have not been received by a prescribed time; production of tags for bindery use; orders for new subscriptions and a renewal of the entire subscription list; financial records showing categories of expenditures by funds, by subject, by language, etc.; lists of materials not owned by the library that are needed to fill in gaps in holdings. Current efforts are aimed at producing all of the items above, but no one system does. Very few institutions have attempted to integrate work in this area with automation in other aspects of their operations.

4.7 SPECIAL COLLECTIONS AND MATERIALS

4.7.1 Description

Libraries handle a wide variety of materials, in addition to books and magazines. Some libraries include the functions of museums, with collections of manuscripts, letters, art objects, etc., all of which demand special treatment.[15] Some materials are given to libraries with restrictions on their use that the library must observe. Frequently, the physical items are more important than their intellectual contents, e.g., rare books, manuscripts, etc.

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[15] To group these functions under the term "museum" does not imply that they are not used by scholars.

Some special collections are easier to categorize for subject use than book materials. For example, maps almost always refer to some geographic area that can be identified, if necessary, by precise coordinates of latitude and longitude. Art and architecture slides always refer to either a geographic location or a physical object. Although such materials may have a subject orientation that must be identified, subject use is much more limited than it is for book materials. The same is true for phonograph records.

Special collections usually impose special storage requirements upon libraries. Both manuscripts and some kinds of books must be kept under controlled environmental conditions or they will disintegrate. (Even ordinary books are not particularly long lived but they are usually more easily replaced.) Other materials do not necessarily need a special environment, but must be protected from public access because of their rarity or fragility.

4.7.2 Applications of Technology

A great deal of specialized equipment is needed for the use of materials such as phonograph records, slides, and maps. Libraries typically use whatever equipment is commercially available, both for display and for storage. Better equipment than is currently available undoubtedly could be developed specifically for libraries.

A number of fairly new academic institutions, e.g., Oral Roberts University, in Oklahoma, and Oakland Community College, in Michigan, are attempting to develop learning centers built around highly sophisticated and complex audiovisual equipment that has been especially designed to handle film strips, language tapes, video tapes, programmed lesson materials, etc. These institutions feel that if the library is to remain a significant part of the academic enterprise, it must involve itself in handling these materials and in processing traditional library materials into new forms that coordinate better with the audiovisual approach. There is some indication that there may be more interest by libraries in the use of these special forms of materials and equipment. This appears to be necessary to avoid competition between "media" personnel and librarians on the campus.

Libraries that handle special collections as their prime function are few in number, considering the total number of libraries in the country, and some persons have wondered whether such libraries need be considered in relation to the "national" problem. There are, in fact, some profitable lines of action that could be taken, with better application of technology, to improve the use of some of the special collections. For example, union catalogs have been produced for certain forms of rare materials, such as manuscript collections. It is now well within the state of the art to develop a truly comprehensive union catalog or national inventory of rare materials. Such a catalog would be widely useful and its maintenance relatively simple, since, compared with regular library collections, the growth of these special collections is not very rapid.

4.8 IMPLICATIONS FOR FUTURE APPLICATIONS OF TECHNOLOGY

It seems clear, from the foregoing examination of current applications of technology to libraries, that more and more libraries will soon be seeking to use data processing equipment to support various aspects of their operations. Some will do so in the hope of saving money; others may do so primarily to improve their operations and service. The latter is probably a more realistic goal. Use of data processing has not saved money for many libraries yet (52). However, it has enabled them to improve operations that they considered critical, to stabilize the number of employees and sometimes to maintain certain operations which were ready to break down under continued manual operations and increasing workload. Machines may help to alleviate the recognized shortage of manpower in libraries long before recruiting and educational programs are able to meet the challenge. Too, despite some conspicuous failures, there is sufficient evidence to indicate that use of machines can improve service to library users. in ways which additional manpower cannot. Judging by the CRS survey (35) cited earlier, many near-future applications of technology to libraries are likely to be largely on a "hit-or-miss" basis, with each library focusing on its most pressing current problem. This is an understandable tendency; yet the greatest potentials of technology may have to do with functions or services that are not currently being performed by most libraries. For example, most libraries have tended to be concerned much more with the monograph than with any other physical carrier of information or data, in spite of the fact that the number of monographs published each year is relatively small compared to other printed materials: periodical issues, report literature, government publications, etc. Although numerous local and regional union catalogs of monographs exist, and there is even a National Union Catalog, there are no union catalogs available for such materials as documents from the United States Government Printing Office. Use of existing technology could greatly enhance access to such documents. If the depository list of the Superintendent of Documents were to be published, using computer-controlled typesetting, as part of the Monthly Catalog issued by the Government Printing Office, depository libraries would no longer need to maintain their own catalogs (which consist largely of simple inventory files, rather than full-fledged catalogs, as are available for monographs). Technology could also improve access to other kinds of non-monographic materials.

Technology can also be exploited for the extension of typical library activities to serve certain user groups better. For example, Project Intrex at MIT is examining (among other things) the expansion of the descriptive and subject cataloging of library materials, so that catalog data available to potential users will include evaluations as well as strict descriptive indications (87, 96). Undoubtedly, other efforts will be undertaken to expand existing library operations into new areas that have not been feasible in the past because of limitations in the equipment and methods available. This raises the question: Is it not possible that entirely new areas of service could be identified with subsequent creation of appropriate techniques and equipment? Without question, libraries of all types, as they are now constituted, are exceedingly valuable to our society. But how much more valuable could they be if there role were seriously examined, with a particular view to the development of new concepts of services such as continuing education (47)?

Another aspect of libraries that one may not immediately associate with technology is their organizational structure. This structure has traditionally included operational and service functions, but might not the current and new technology of the near future offer the possibility of changing the entire organizational concepts of libraries? Do they need to continue operating in the traditional manner, with the traditional departments? Several libraries undertaking automation programs have found that existing divisions could be efficiently combined into larger operating units when data processing equipment was put to work. If this aspect of library operation and management were given the attention it deserves and made the focus of design studies, could not significant improvements be expected in the total library system?

Just as computer technology provides the opportunity for individual libraries to think in terms of larger units of operation, so, too, does it provide the opportunity for groups of libraries to work together in ways that would be difficult, if not impossible, without the use of advanced technology. Although most of the current library automation efforts are oriented to the individual library, the time would appear to be ripe for many of these disparate efforts to be channeled into a better-focused national effort that would seek to bring all aspects of our technology--not just the techniques of data processing--to bear on the problems of library operations.

In this vein, a recent reviewer of library automation efforts has written in the 1967 Annual Review of Information Science and Technology (84):

> "In the past, much of the automation literature has consisted of reports of individual and quite isolated projects. This was perhaps necessarily so because the vision to see the relationship between the new technology and bibliographic processes was limited to a few individuals who often seemed to be 'marching to the tune of a different drummer'. This may be the classic pattern of technological advance, but this reviewer believes that to continue to regard automation as the plaything of an avant garde elite is dangerous. We have reached the point where further achievements will depend on the ability of a lot of us--librarians, computer specialists, system analysts, and information entrepreneurs of various ilk --to march, at least occasionally, in step."

In her survey of recent progress this reviewer gave primary attention to literature that described cooperative movements or literature that presented an honest attempt to discuss, not so much an individual project, but the principles and concepts involved. She summarized things this way:

> "To this reviewer the single most important facet of the literature of 1966 is that it clearly reveals that there is a vast and growing number of marchers, that national and international ventures are being planned and some are even under way, that there is an ongoing search for a *modus vivendi* between the library world and that of the specialized information center, and that at least minimum standards for machine-processable data are almost upon us."

It would appear that both the full exploitation of technology and the library needs of society will demand a reorientation of libraries from individual, isolated, operating units into a cohesive national (or even international) structure capable of offering a given level of information service at any point in the nation.

5. FUTURE DIRECTIONS IN LIBRARY OPERATIONS AND SERVICES

5.1 INTRODUCTION

Many papers have been written on the libraries of the future. They vary greatly in their conception of library users, service requirements, desirable operational procedures, and applicable technology. They also vary greatly in their conception of the time scale on which such libraries can be developed, and in the depth of their grasp of the tremendous technical complexities involved in actually achieving highly advanced library applications that fully exploit the potentials in presently existing hardware and software technology.

Underlying many of the details in these conceptions are two fundamentally different approaches to prognostication. One approach stresses what it is theoretically possible to achieve, given massive infusions of effort and money and rapid acceleration of technological development. Projections along these lines have pictured a norm of large libraries making extensive use of computers for all their internal processing, and individual members of the using public seated at consoles conducting searches or otherwise interacting directly with massive files of computer-stored material.

The other, more realistic approach toward prediction stresses a linear extrapolation of current trends. It charts the probable direction of future library operations and services as a straightforward extension or growth from the present, on the assumption that the purpose, organization, staffing, funding and operations of libraries will not change radically within the next five to ten years.

Each kind of prediction has important uses. Glimpses of a possible future fire the imagination, help to widen one's horizons in thinking about library problems, and, in many instances, identify desirable paths for research exploration. Such glimpses also help to attract funding that might be more difficult to obtain for more "pedestrian" research or development. The critical weakness of this approach is that it often points to goals so distant and so demanding of social and technical changes that they are unlikely to be accomplished. In some instances, all-encompassing plans can derail or forestall more modest but nevertheless important improvements of present circumstances. Some of the more visionary schemes may also create devices and techniques especially appropriate to a select class of library users--an elite, so to speak--but that afford little improvement to the vast majority of patrons.

Predictions based primarily on extrapolation of the present are useful aids to short-range planning because they are firmly rooted in present operations and thereby generally take more adequate account of problems of transition from the present to the future. Such predictions are more likely to be borne out than more far-reaching and visionary predictions because they demand less on the part of society, the government, and technological innovations. The danger of the more conservative approach is that it may encourage preservation or mere "mechanization" of current procedures in some circumstances where only radical overhaul can make a significant and worthwhile change.

This section offers two views of the near future. One is primarily an extrapolation of current trends, intended to convey some picture of library operations over the next ten years if there is no massive infusion of energy, funds, and direction into the library picture. The other view is of a reasonably possible future, with the emphasis on operations and services that have some potential meaning to the main body of libraries, rather than the relatively few, very specialized libraries that have ample funds for experimentation with advanced technology. While it may appear that both views tend to err somewhat on the side of pessimism, the history of the application of technology to problems of information handling suggests that undue optimism may be a more serious error and a greater source of disappointment.

Whatever approach one chooses to take toward prognostication one must keep in mind that, during the next ten years, there will be an increasing demand for library services of all kinds, not only because of the population growth but because levels of education and needs for vocational training are increasing. One can foresee that over the next 10 years a much larger proportion of the population of the country will be educated, either in an academic manner or in vocational or technical training, than has ever been the case. Many of them will require a continuous regime of study to keep up with the changes and demands of their work. Thus, there will be a great pressure for public libraries to acquire, represent, store, and make accessible to their publics new and varied materials, including magnetically recorded TV films, a wide range of microforms, and other media not commonly handled today.

5.2 AN EXTRAPOLATIVE VIEW OF THE FUTURE

5.2.1 The Demand for Services

Given only the extrapolative prediction, it is doubtful that more than a handful of public libraries--state, county, or city--will be able to respond to the pressures just described. Many public libraries cannot now cope adequately with books and magazines, and cannot be expected to do better with the newer media. Too, the increasing workloads are likely to cause further deteriorations of the librarian's capacity to help readers in the selection of material. It is generally acknowledged that there is much out-of-date or erroneous material on library shelves. Many libraries have paid little attention to this problem, believing that their function is only to provide a collection of materials and a place to use them. Weak or nonexistent guidance is explained in terms of free access: if materials are available on all sides of a question, anyone can make a correct selection of materials to use. Since most libraries will not have the manpower to do anything more than attempt to keep up with increasing workloads, little change can be expected in this area. To the extent that they can be, the demand for information services will be met, if not by libraries, then by other agencies. The trends evident in serving specialized user groups will become manifest in the general populace in some of the more affluent areas. Specialized information centers may spring up to compete with the library, not only in giving service, but, more importantly, in obtaining funds. (At the Federal level, the specialized information analysis centers being established by the National Institute for Neurological Diseases and Blindness are indicative of this trend. These centers coexist, and perhaps actively compete, with established medical libraries.)

One may project some of the same consequence for educational libraries of all types as for public libraries. The service loads on college and university libraries, however, are likely to be much heavier in the future, compared with the rise that might be foreseen for other types of libraries. Most of the 50 million or so students currently in primary and secondary schools will reach college age during the next decade, and an ever-rising percentage of the population will go to college. In addition to the sheer problem of numbers, emerging concepts of broader educational service--as embodied, for example, in the library-centered college concept now gaining favor--will add to the range of service demands.

There are whole categories of information, such as graphics, that cannot be adequately transferred by means of the printed word. If the library-centered-college concept is to flourish, then the appropriate transfer media for such information must become an integral part of the library armamentarium. This is not likely to happen in more than a small number of well-financed institutions, if the present competition for academic funds continues.

The increasing demands for service from public and educational libraries are likely to have an impact on special libraries. Special libraries have usually been able to draw upon the resources of other libraries,[16] but with these other libraries hard-pressed to meet the demands of their own users, assistance to special libraries may not be as readily available. In addition, of course, the special libraries will face ever-increasing demands for the highly specialized collection, description, and handling[17] of information of many types and forms that are not characteristic of other types of libraries.

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[16] Generally, large academic libraries located nearby.

[17] Specialized handling refers to handling by specialists with a particular clientele in mind, e.g , chemical information handled by librarians with a chemistry background, for chemists.

Considering the nation's libraries as a whole, and given a straight-line projection of current operational methods, it is not unreasonable to believe that the overall effectiveness of library services ten years hence will be considerably poorer than it is today. Something more than straight-line improvement seems indicated, if the present quality of service is not to deteriorate.

5.2.2 Available Technology

During the next ten years, libraries will be able to choose from a very sizable array of equipment and procedural technologies to help them in acquiring, processing, and storing materials and in providing reference and other services to their users. The most important class of equipment, from the standpoint of processing, is data processing equipment, especially computers. Even without any acceleration of development, computer systems are increasing rapidly in speed and storage capacity and decreasing in cost, so that many more libraries may find some amount of computer support within their economic range. Some libraries may choose to rent computers or purchase them outright; others, particularly small libraries, may purchase "shares" in time-shared systems or use service bureaus.

From the standpoint of storage and distribution of materials, probably the most important kinds of equipment developed are those dealing with microforms and reprography. Microforms are becoming increasingly inexpensive to produce and handle, and equipment for reading and reproducing microforms is steadily improving in quality.

During the next five to ten years, even without any acceleration of development effort, there may be very well-developed techniques for the use of computers or computer-supported systems for various aspects of technical processes and information retrieval in libraries. Fully automatic processing of language data still poses severe technical problems, but a variety of computer-aided language-handling procedures of quite general applicability may be available to libraries and other information facilities. The chief obstacles to widespread use of these will be the cost and the limited capabilities of library staffs to work with, and take full advantage of, computers. It would be necessary for libraries to have programmers and computer operators on their staffs.

5.2.3 Applications of Technology[18] within Individual Libraries

Of the approximately 25,000 libraries in the U.S., apparently only between 2 and 3 percent are presently applying data processing procedures to some parts of their internal operations. These applications are about evenly divided between punched-card operations and computer-based operations. During the next five to ten years, we may expect to see a substantial increase in the percentage of operations using computers, particularly for educational and special libraries.

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[18] All figures given in this section refer only to use of data processing or related technology. No adequate projections were thought feasible on other uses of technology, such as microforms, copying devices, etc.

About 6 percent of educational libraries are using some form of data processing, and we may see well over 25 percent of them using data processing equipment within the next five to ten years. Public libraries presently account for very little use of data processing--one half of 1 percent of them apparently use it--but it seems likely that the figure could rise to 10 percent within the next decade. Four percent of special libraries currently use data processing; this figure will probably rise to about 10 percent also.

Most of the libraries using some data processing have concentrated on technical processing of materials and hardly at all on service operations other than circulation; it is likely that this emphasis will persist.

The character of the use of data processing will differ from one type of library to another. Most of the larger public library systems will probably adopt computer techniques for some portion of technical processing operations and for such functions as circulation and materials control, binding, and records. This will be necessary because, thanks to the greatly increased support of the Federal Government through the higher education bills and other specialized legislation directed at improving library services, the variety and comprehensiveness of public library collections can be expected to increase significantly in the next ten years.

The use of data processing technology is also likely to be accompanied by a rather thoroughgoing integration of managerial record keeping, payroll accounting, and the like, in support of the budgeting and recording process. Although various kinds of statistical and other record-keeping operations in public libraries will be increased, they are likely to be tied, as now, to internal operations for the accumulation of budgetary and administrative information, rather than for knowledge of and adaptation to the needs of their users. The larger public libraries (especially state libraries) are also likely to engage in a shift from card catalogs to book-form catalogs for some categories of materials. For smaller libraries, we may expect to see only a relatively slow, gradual increase in the use of data processing equipment.

Educational libraries will probably show the same general pattern of use of technology as the larger public libraries. The larger university libraries will adapt data processing to more of their technical processing work, and there will be an increased use of book catalogs and mechanized circulation control, but the effects on reference facilities and service will be relatively small. Secondary school and elementary school libraries will engage in cooperative ventures for purchasing, cataloging and other routine record keeping within the library, but the nature of services from the user standpoint will not be greatly different from those given today. Special libraries, particularly those that operate as information centers, will be able to draw on data processing and other technological advances to a much greater extent than will public and educational libraries. Because of their particular service goals, they emphasize the reference and retrieval aspects of their operations. In particular, they are likely to make use of the capabilities currently being developed for handling large data bases, i.e., large collections of relatively well-formatted data. There is also likely to be an increasing use of selective dissemination or other selective alerting procedures.

5.2.4 Applications of Technology to Networks

It is widely recognized that the ability of individual libraries to acquire, process and make available all of the materials demanded by their users is fairly limited. This recognition has spurred work on various kinds of cooperative systems and, more recently, on networks to interconnect libraries of various kinds. Although computer technology needs to play a role in these networks, the primary dependence is on communications and reproduction technology. Current work on networks has stemmed not as much from breakthroughs in these or other areas as from the availability of funds for experimentation. If funds continue to be available, we can expect to see much more in the way of network development.

The network currently being developed in New York State to link public, educational, and some special libraries is a prototype of one kind of network that we will certainly see within the next five to ten years in several of the wealthier states, such as California, Illinois, Indiana, Massachusetts, and Pennsylvania. Other types of networks that we can expect are subject-specialty networks, such as those for medicine (MEDLARS centers) or law, and educational networks of the sort being considered by EDUCOM. It is difficult to predict what proportion of the universities will be tied into an EDUCOM network in the next decade--perhaps no more than the 20 or 25 larger universities. At any rate, at the very maximum, no more than one-third of the libraries in the United States will be tied into such networks. To put it another way, if network development continues at the present rate, it seems unlikely that 1977 will see an integrated nationwide system for announcing, finding, searching, and transmitting documents.

There are network-like operating arrangements, i.e., cooperative systems, already in operation and it would be quite possible to implement more comprehensive ones, e.g., centralized processing centers, within the next decade. More cooperation is likely to be realized, but not at a rate that promises full operational capabilities by 1977. The relatively slow rate of progress on networks and other cooperative systems does pose one danger. With increasing use of data processing technology, particularly in the larger research and special libraries, we are likely to see a proliferation of specialized service centers, information and documentation centers and the like, using a number of unique and incompatible practices and procedures and competing with libraries for personnel and funds. It seems likely that the consequences of such incompatibility can only be forestalled by greater movement than we presently have toward coordination and establishment of common standards.

5.2.5 Summary of the Extrapolative View

Projecting current trends into the next ten years, one may expect to see the large majority of libraries operating much as they do today. The number of libraries using advanced data processing technology will certainly increase, possibly from the present 2 to 3 percent to 10 or 15 percent. Considering the growing demands for library service, this level of use of advanced technology will not result in any net improvement in library service for the majority of individual libraries. Instead, a deterioration of service is likely to occur because of increasing costs and competition for available manpower. Large categories of informational materials will continue to be neglected to a great extent, by libraries that are already coping inadequately with traditional printed materials. Thus the majority of libraries will not be able to contribute significantly to the improvement of information transfer. The truly significant improvements that could come from network or network-like arrangements seem very unlikely to come about by 1977, without some form of accelerated planning and support.

5.3 A CONDITIONAL VIEW OF THE FUTURE

While an extrapolative view of future libraries sees most of them continuing to operate largely as independent entities, quite another view is possible. This view is conditional on aggressive planning, thorough exploitation of technology, and significantly higher levels of financial support of libraries. Under such conditions, one could envision a tremendous improvement in library service throughout the United States. The conditional view of the future sees libraries as elements of one or more integrated networks. Each library would, as now, provide such services as its operating budget would allow, but its participation in the networks could enable that budget to go much farther than would a largely independent operation. Thus, it could provide its own staff personnel with better information-finding tools, with relief from the burden of cataloging certain materials already appropriately cataloged through the network, and with computer-based, network-supported facilities for handling a greater number and variety of reference problems. The library's users would also be provided with better information-finding tools, with a much wider variety of materials (e.g., slides, microforms and videotapes) than are currently available, and in some instances, with an opportunity to interact in a very direct way with the information store, including machine-stored data of a tabular or encyclopedic nature.

5.3.1 The Role of Books and Other Media

While it is customary, in some pictures of the library of the future, to downgrade the role of books and other printed documents, realism demands recognition of their continuing central role, not because other information carriers are unavailable or too expensive, but because books are exceptionally efficient devices for holding sizable stores of information. Like the telephone directory, they provide a degree of access to information that would presently be difficult or impossible for machines to match on a cost/efficiency basis. The library of ten years hence will still be comprised largely of printed materials; however, it could take advantage of machine-stored data, microform representations, and other media to provide the kinds of service that cannot be provided as efficiently, economically, and satisfactorily through the printed word.

Future libraries are likely to make much heavier use of other media, such as audio tapes and phonograph records, slides and films, holograms, and videotape recordings, that carry certain types of information that the printed word cannot carry as well, if at all. Nearly all educational institutions have record and tape players and sound projectors, and some are acquiring videotape equipment. Although the latter equipment is not nearly as inexpensive as ordinary sound projectors, the expenses for producing videotape are much less than for film. Too, there is growing expectancy of a market for videotape units intended for use with home television sets. These could, of course, handle videotapes borrowed from the library.

5.3.2 Cooperation and Network Operations

The library of the future could find its selection, acquisition, and interlibrary loan processes for all media materially aided by the availability of such tools as a national bibliography and a current National Union Catalog. By current, we mean publication on the time scale of a weekly newspaper, rather than on the scale of several months that is presently typical. With such tools--which it is certainly technically possible to develop--and the communication net, libraries could easily identify, locate, borrow or purchase a copy of desired material. Appropriately accelerated developments along the general lines of the Library of Congress Project MARC could relieve libraries, in whole or in part, of what currently amounts to a greatly redundant cataloging effort. While individual libraries might not need or might not be able to afford direct computer assistance in processing, they might well belong to and depend upon local or regional networks which, in turn, are part of larger networks.

5.3.3 The Library as a Distributing Agency

In the future some libraries, particularly educational and special libraries, are likely to shift from being primarily a lending institution to being more of a distributing agency. We have already reached the stage where the cost per book of library circulation control is almost as large as the price of a paperback book. Thus, with the prospect of replacing or copying full-sized or microform materials easily (the latter a rapidly developing capability), some libraries will prefer to give material away rather than to lend. Many more of them may also become sellers of microfilm copies. Some of the traditional antipathy to microfilm, based on low-quality images and the cost of viewing equipment, will certainly disappear as these problems are ameliorated and as libraries decide to grasp the opportunity to have much larger holdings without compensatory demands on their physical space or processing procedures. Some record keeping will undoubtedly be required in connection with appropriate compensation to copyright owners; this need not be a complex matter, particularly if the library is tied into a network supported by data processing for such routine accounting matters.

5.3.4 Automated Document Processing

While relatively few libraries are likely to be engaged in automatic or machine-aided indexing, abstracting, classification, translation, and the like, during the next ten years, many are likely to be beneficiaries of such processing by specialized elements in the network. Although there are significant technical problems in this area that are not likely to be completely resolved in the next ten years, the more important barrier has been economic — the sheer cost of putting large amounts of text in machine-readable form. Expected improvements in optical readers will help to some extent, but even greater help will come from new publication techniques that use computers and provide a machine-readable version of the printed material. Logical changes in the copyright law might give publishers an economic incentive for turning over such machine-readable material to indexing and abstracting agencies or the other organizations serving particular networks. Such agencies will have the equipment, trained personnel, and familiarity with the specialized subject matter necessary to make this kind of arrangement advantageous to all.

5.3.5 Expanded User Service

All of the improvements in acquisition, cataloging and other aspects of technical processes that one can foresee in future libraries spell better service to users. The first kind of improvement will see computers used to provide services within the library that are provided today by intellectual effort. The second kind of improvement will allow libraries to offer new search and retrieval capabilities to certain classes of users and to the librarians and to provide, particularly in educational and special libraries, a much higher order of access to reference materials, either in digital or photographic form. Large systems for the retrieval of documents or specific data are already operational, some in versions that permit direct searching by the user sitting at a teletype anywhere in the United States. Such interactive devices, with output speeds at least twice that of current models, will be widely available and no longer a curiosity in some large libraries. More broadly useful consoles with rapid textual display capability will also be available in some special and educational libraries, although their cost will still be too high to have many such stations. Their primary use is likely to be for reference questions that are mediated by staff personnel.

Some kinds of information, such as census or election data, that are now available primarily in book form are likely to be made available to libraries in machine-readable form. With modest extensions of present capabilities for manipulating computer-readable data bases, a wide range of new information can be made accessible to library users. Certain kinds of tabular, dictionary, biographical, or encyclopedic data for which there are common and easily defined access paths might well be available, perhaps on-line, in some research-oriented libraries. It is not out of the question to expect some modest amount of manipulation and/or statistical capability associated with such data stores; computer programs embodying such capability are already commonplace in many universities and research facilities.

Libraries of all types could change their role to a more active one by adding some of the features of the specialized information analysis center. Libraries could actively disseminate factual political data, the activities and plans of public and corporate institutions within their service area, schedules of significant local, national, and international cultural and scientific events, etc. Libraries could have more concern with information as a commodity rather than being concerned, as now, with the physical carrying of the information.

Libraries of the future may also provide dial-up reference service. Every telephone becomes, in effect, a receiving console connected to a library. Lessons by telephone have already been used by the educational community in Colorado and the medical community in Wisconsin, and there could be greatly increased use of this type of service within the next ten years. In the same class as telephone messages is the use of slow-scan TV to transmit information to individual homes. The advantage of slow-scan TV is the reduced requirement on the communication lines. It is quite likely that this type of transmission will come into demand when the videophone becomes a general item of telephone equipment. This will permit a much broader kind of library service to the public than most libraries currently envision.

Given continued growth of known pressures for change, three identifiable trends may well combine to augment the service concept of many libraries. One trend is the broadening needs for education and re-education brought on by accelerated technology. A second is the growing awareness of the need to pre-package information into maximally useful units. The third is the bandwagon effect that is created as an increasing number of people find the library very useful and easily accessible. Together these trends will create a massive pressure for libraries to put much more emphasis on educational materials, programs, and functions. Facilities may be modified to permit them to handle much larger volumes of course-sequenced materials, examinations, exercise stimuli, and self-diagnostic devices. These could serve adult education objectives of correcting deficiencies, retraining, and supplementary education, which will become important for increasing numbers of citizens as our society undergoes changes wrought by science and technology.

5.3.6 Summary of the Conditional View

Assuming adequate planning support and aggressive exploitation of technology, the next ten years could see a very great improvement in library service throughout the United States. A most dramatic change could be in improved and expanded communication and cooperation among libraries. Communication networks could provide data processing capabilities to smaller public, educational and special libraries; reduce duplication and costs of purchasing and processing; and, at the same time, increase their service to users through rapid interlibrary loans, improved reference support, and the outright distribution (rather than loan) of certain kinds of material. Active dissemination of certain types of information could be commonplace. Nonbook materials could be exploited by libraries of all sizes and types, and could be available virtually anywhere in the nation.

5.4 PROBLEMS OF TRANSITION

Both of the views of the future outlined above involve difficult problems of transition from the present to a desirable future. Some of the technical problems related to equipment and techniques have already been discussed (in Sections 3 and 4). There are also a number of major problems that are not necessarily technological in nature. These have to do with training, the development of standards, and the development and implementation of government policy. Possible solutions to some aspects of these problems are discussed in Section 6, in the context of a larger program of action. The primary purpose here is to identify issues that must be given special consideration if the potentials of modern technology are to be exploited effectively.

5.4.1 Training of Library Users and Personnel

There are serious and persistent weaknesses in the knowledge and ability of the libraries' clientele to make effective use of library services and materials. Library customers are rarely equipped to make efficient use of the card catalog or other indexes to the collections, reference materials such as bibliographies, periodical indexes, abstract services and other aids to documentary research. Too, most library users do not fully appreciate that some skill and intellectual labor are required for effective searching with conventional library tools. The development and application of advanced technology to library operations not only changes, but in several respects complicates and adds to, the problems of bringing to the library user an adequate awareness of sources and devices as well as the skill to make them serve his increasingly wide-ranging needs for documentary access and service.

Perhaps a more serious obstacle to the application of advanced technology to library operations has been the lack of adequately skilled and trained staff, experienced both in the requirements of library operations and in those of technology, whether in computing, reprography or communications. The education and training of professional librarians and other library personnel has ill-prepared them to appreciate or assimilate the capabilities and promise of the new technology. At the same time, persons skilled in the computing art and in other aspects of the changing technology are rarely equipped to deal with the specific and complex requirements of library operations.

If technology is to be exploited effectively for library operations, it will be necessary to give considerable attention to means of helping library users to understand and exploit library services and facilities and to bring library personnel to a state of skill and preparedness for the new developments that technology will bring. Technology itself offers some promise of providing some of the tools to facilitate such training, e.g., demonstration via TV film, time-shared consoles, and computer-aided instruction. As the library systems of the future are developed, care needs to be taken to include devices and techniques for self-instruction and training of both library users and personnel.

5.4.2 Standards, Compatibility and Convertibility of Data

New technology applicable to library operations is being developed at a rapid rate, particularly computer technology, which is increasingly being adopted by some of the larger libraries. In order for this technology to be maximally effective, especially for network operations, there must be some degree of compatibility in data descriptions and programs for processing computer-readable materials. Without some degree of standardization, or provision for conversion, data files and programs developed at one installation are unlikely to be usable at another, and a great deal of material is likely to have to be keyboarded several or many times.

The desirability of some degree of standardization has long been recognized in the library field and a number of standards have been created, a noteworthy example being the catalog card format of the Library of Congress. There are a number of committees and subcommittees of the United States of America Standards Institute that are concerning themselves with standards on such topics as Reference Data and Arrangement of Periodicals, Basic Criteria for Indexes, Periodical Title Abbreviations, Basic Criteria for Filing, Basic Criteria for Abstracts, and Machine Input Records. Such committees represent one avenue for achieving the necessary standardization.

Another feasible approach is to accelerate the development of certain techniques in large and influential libraries and let the resulting products provide _de facto_ standards. (A large number of libraries have voluntarily accepted the Library of Congress card as the standard catalog card because of the inconvenience and expense of using any other standard.) Both of these approaches to standardization may need active consideration, if the many separate and independent library organizations are to achieve adequate cooperation and communication using the new technologies.

5.4.3 Legislation, Government Policy, and Continuity of Planning

A year or two ago, it was estimated (23, 28) that about 900 million dollars a year was being spent by various parts of the American public and private sectors for library service. Taking into account recent and increasing support from the Federal Government, the current figure is probably about 1.3 billion dollars. This rather massive investment has been made largely without a national program in mind. Thus the present legal, political, and jurisdictional structures are not ideal from the standpoint of integrated planning for library development.

If viable national networks responsive to the full range of library user needs are to come into existence, libraries in all of the states must have the capability of contributing to and interacting with those networks. For this to come about, Federal legislation will be needed to ensure adequate support for these libraries and to eliminate statutory, jurisdictional, and administrative obstacles to such participation. Legislation may also be needed to provide for development of a practical mechanism for the wide dissemination of document facsimiles and for compensating holders of copyrights to such documents. It may, in fact, be desirable to consider legislation that sets, as a matter of national policy, a minimum standard of library service at any place in the nation.

On the Federal level, there is a need for a thorough and continuing review of executive orders and statutes and coordination of proposed legislation, particularly laws that require matching funds and/or operational support from recipients of Federal monies. Ideally, Federal legislation should permit individual systems to operate more effectively, but should not encourage abdication of any responsibilities they have already undertaken. Legislative efforts by the Federal Government should take advantage of the momentum and funding of present efforts rather than simply supplanting them. Otherwise, legislation intended to provide libraries with additional funds may merely find one source of tax support replacing other already existing funds.

In the discussion of present and projected library requirements (Section 2), it was pointed out that the development of networks, or other kinds of systems involving extensive interdependences, would very likely require some kind of coordinating influence or coordinating body. Such a body would need to be responsible for (1) keeping informed on the existing and prospective state of library service, (2) planning for improved library service at both national and local levels, (3) developing legislative proposals, and (4) coordinating various government projects affecting library service via grants and contracts. From the standpoint of support, it seems evident that only the Federal Government has the position and resources to manage the coordination effort necessary to bring networks into existence on a large enough scale and in time to meet emergent requirements of the future, as well as present requirements not yet met adequately.

6. A PROGRAM OF ACTION

6.1 INTRODUCTION

Previous sections have discussed present and prospective uses of technology in relation to library services and the operations that support them. The point was made, in those discussions, that there are a number of areas of library operation in which the potentials of various kinds of technology have not been fully exploited.

Section 5 provided estimates of the likely role of technology in libraries some five to ten years hence, both with and without some kind of accelerating influence. This section outlines a recommended program of action which could be undertaken if the decision were made to accelerate the improvement of our libraries and if adequate support were provided for that purpose. The program focuses on the entire complex of libraries, without particular emphasis on any one type of library.

6.2 CHOOSING A PHILOSOPHY OF PLANNING

A primary question confronting both individual libraries and organizations concerned with interlibrary activities is not only whether to use technology but what kinds to use and how to use them. As indicated earlier, there is no inherent requirement for the use of technology; technology is simply a means--and not the only one--to achieve certain ends derived from the broader goals of our society. Some library problems can be solved more effectively through changes in technical or administrative procedures than by the introduction of technology per se. On the other hand, some of the proposed new operations involving interlibrary cooperation are unthinkable without extensive use of technology.

The exploitation of technology to improve library operations and service can be approached in several ways. Three possibilities offer themselves: (1) to let things evolve, just as they have been evolving for many years; (2) to design and implement a highly integrated nationwide library system; or (3) to attack selected problems whose solution might have widespread beneficial impact. Each of these approaches has some commendable features; obviously some aspects of each approach could also be combined, and the combination might prove more fruitful than any single approach.

6.2.1 Letting Things Alone

The first approach (letting things alone) does not imply inactivity; rather it places reliance on the mechanisms already being used to improve library operations and service, without attempting to accelerate the rate of improvement. A major advantage of this approach is that it requires no drastic change in present activities, concepts of service, funding, or patterns of involvement of the Federal Government. It takes advantage of some of the benefits of the "squeaky wheel" concept, permitting individual libraries or groups of libraries to apply remedies selectively at the point of greatest or most obvious trouble. It also avoids some of the waste that nearly always accompanies massive system design efforts in areas where goals are unclear, not universally shared, or subject to change. The major disadvantage of this approach--and it is a very serious one--is that in spite of likely improvement, the nation's libraries as a whole would almost certainly lose ground, in the face of increasing processing loads and demands for service. Since this is not an acceptable prospect, letting things alone would not seem to be a satisfactory course of action.

6.2.2 Developing a Single Nationwide System

The second approach would plan and develop a nationwide, highly integrated library system. This approach implies a massive planning effort and a highly organized transition from the present situation to a more desirable one. The process ordinarily requires:

(a) Formulation of a clear, detailed, and specific statement of goals and requirements.

(b) Formulation of a set of criteria by which the existing system and any proposed changes can be evaluated.

(c) Evaluation of the present system in terms of the previously specified requirements and criteria.

(d) Design of a system to achieve the specified requirements.

(e) Design of the plan for transition to the specified new system.

(f) Implementation and evaluation of the new system.

(g) Modifications (if required) to the new system to assure that it meets the objectives.

The so-called "system development" process, of which the foregoing elements are major steps, has proved to be a valuable tool for designing large, complex systems to handle massive amounts of data. Because it is an orderly process, it helps to assure that major requirements are known and agreed upon, that the available resources (personnel, money, equipment, procedures, etc.) are known, and that various alternatives for meeting the requirements are not overlooked. This process does not guarantee that the correct decisions will always be made, but it helps to reduce the likelihood of making wrong ones.

The application of a system development approach to the library problem might have two important benefits. One would be to permit certain kinds of operations that are not likely to just evolve, at least not rapidly. If such operations are to exist, or to exist as soon as they are economically and technically feasible, they must be planned for. A second major benefit of systematic and system-wide planning is the savings in cost and time by avoiding duplication of effort. Hundreds of libraries and information facilities are currently engaged in independent state-of-the-art appraisals and implementations of various automation technologies, and undoubtedly a significant number of these are, to some extent, redundant. Some groups of related libraries that are altering their operations to provide greater compatibility with each other are, at the same time, becoming less compatible with other libraries. There is, in short, a less-than-optimum use of funds, when one views the nation's libraries as a whole.

On the other hand, the system development approach has some very stringent requirements that must be met before it can be applied to library system planning. The three most important requirements are: (1) formulation of a clear, detailed and specific statement of goals or system requirements, (2) sizable and stable funding, and (3) effective management.

With respect to goals, it is clear that no common, agreed-upon goals of the nation's libraries have been formulated, at least not in terms that a designer could use to develop concepts for a desirable system or group of systems. It is indeed questionable whether one can develop such a set of goals for all libraries. At this point in time, agreement on common goals could probably be achieved only among particular subsets of libraries, such as public or research libraries.

A massive system development effort also requires massive financial support. Whereas high and stable funding is provided for large military systems, such as, for example, the U.S. semiautomatic air defense system, it is not at all clear whether the improvement of the nation's libraries would have a sufficiently high priority over the next five to ten years to permit a full-scale program. A system development effort without dependable funding might in some respects be worse than no systematic planning at all, because it could inhibit, postpone or derail other potentially worthwhile efforts in library improvement.

The most crucial problem is that of management. There have been a number of notable failures or disappointments in system building, large and small. If there is a single most damaging factor in these instances, it has been the lack of top-level management understanding and control. Where responsibility has been abdicated to the system designers, consultants, equipment manufacturers, committees, or even to operating personnel, the results have sometimes been costly fiascos. Is there, or is there likely to be, the equivalent of an effective "top management" for the improvement of the nation's libraries? Considering the large numbers of sovereign entities that comprise the U.S. library community, one would have to say "no." Thus, in this domain, some of the advantages of the standard system development approach are likely to be only illusory, and it might be better to aim for more limited goals and more limited systems, networks, or operating arrangements that can be developed effectively with foreseeable resources.

6.2.3 Supporting Selected High-Impact Projects

The third approach to improving the nation's libraries--and the one that this report strongly endorses--is to identify and support *selected* activities that are likely to have a beneficial impact on all or many of the nation's libraries. A major advantage of this approach is that it recognizes the operational independence of the majority of the nation's libraries while taking advantage of their willingness to participate in interdependencies--such as interlibrary loan systems--that offer mutual benefits. Another important advantage is that this approach does not in any way preclude undertaking *other* projects and programs.

Some high-impact projects could and should be aimed at the development of model subsystems that could later be incorporated into a more fully integrated nationwide system. Five such projects, briefly outlined in Section 6.3 below, are strongly recommended for consideration. None of them is an entirely novel idea; none of them involves technology for its own sake. Rather, each involves a *recognized objective that technological progress has helped to bring within reach*. Each of the projects is technically and economically feasible and we believe that each could have a catalytic effect on the improvement of library service in the U.S.

6.3 RECOMMENDED HIGH-IMPACT NETWORK AND SYSTEMS PROJECTS

In the past, libraries have had rather remarkable success in developing cooperative interlibrary loan and acquisition network enterprises, as well as such representation schemes as the National Union Catalog and *Union List of Serials*. Today, however, these fall short of what could be achieved, with full exploitation of technology, and short of what the nation requires even now, to say nothing of estimated future requirements. Described below are five projects that take advantage of current technology to provide important mechanisms that will ultimately be essential to an integrated network of library systems and services.

6.3.1 A Prototype Network of Regional Libraries

For national networks to operate efficiently, certain nodes in the system must function as major switching or referral points for communication between local libraries and national networks. A system of regional libraries could serve this function. Their responsibilities could include the maintenance of regional union catalogs and bibliographic lists of all kinds; the selective communication of portions of these lists to national union catalogs and lists; maintenance of accounting systems for reproducing copyrighted materials; and extensive reference, referral, lending, and copying services for local libraries. Because there are many organizational and technological unknowns in building networks, it is suggested that a prototype network be established as an operational experiment.

This project could be carried out within a four-year period, along these lines:

> First year: Planning, staffing, contracting, design, and testing by means of simulation or pilot operations.
>
> Second year: Acquisition and installation of hardware, software, and communications equipment; system testing and initial operations between selected points. Equipment installed for this phase would tie together only the regional centers plus selected local service points.
>
> Third year: Procurement and installation of additional equipment to add a larger number of local service points to the network. All points actually tied in would become fully operational during this year.
>
> Fourth year: Addition of more local libraries to the system, so that virtually all of the nation's libraries could participate in the network. All connected points would be fully operational and the network physically complete.

6.3.2 An Expanded, Computer-Based National Union Catalog

The system of regional libraries suggested in Section 6.3.1 would maintain extensive and detailed union catalogs and union lists of all library materials held in local libraries. From these catalogs and lists, a selection could be made for the compilation of a broader based National Union Catalog (NUC). For tasks of this magnitude to be done at all, it appears imperative that the catalogs and lists be produced in machine-readable form. If this were done, systems could be developed to exploit several important capabilities. The catalog could be interrogated directly through electronic communications (using the network involved in 6.3.1); individual libraries could readily create special subsets of the catalog by subject or other kind of access for their own purposes; and, most importantly, the catalog could serve as a basic tool for libraries throughout the country to locate various kinds of materials for their users in a timely manner.

The developmental work for this project could be carried out within a three-year period, along these lines:

> First year: Planning, staffing, contracting, design, and beginning of preparation of inputs in machine-readable form.
>
> Second year: Establishment of local union catalogs, through receipt of machine records from the Library of Congress, plus local input; communication of selected parts to Library of Congress to become part of the national record; and initiation of conversion of the post-1955 NUC to machine form.
>
> Third year: Completion of conversion of the post-1955 NUC and current additions thereto and initiation of distribution in machine-readable form on a regular basis to all parts of the nation. Complete geographical coverage would be achieved by having contributing libraries serve as NUC depositories in all parts of the U.S. By the end of the year, NUC records would be maintained and distributed on a regular and timely basis. Union catalogs would exist in each region, and all would be interconnected to each other and to the NUC.

6.3.3 A National Bibliography

The Library of Congress card service does not cover all copyrighted materials, and the *Catalog of Copyright Entries* is not produced in a form that is satisfactory as a bibliography, nor does it include all publications. With appropriate use of computers, and particularly with use of computer-controlled typesetting or photocomposition devices, a comprehensive and timely national bibliography could be produced. This could relieve many libraries of most of their cataloging effort, provide a compatible input for the *National Union Catalog*, and serve the publishing and book-selling community as well as libraries. This service could also provide all of the advantages of flexibility and adaptability inherent in machine-readable files, and make the task of building responsive networks much easier.

The National Bibliography could be put into operation in about two years, as follows:

> First year: Planning, design, staffing, and preparation of pilot issues.
>
> Second year: Contracting, printing, and dissemination.

The short time-table implies that initial publication and distribution of the National Bibliography could be expected to begin January 1, 1970, on a weekly basis. The Bibliography would list all new publications, both copyrighted and non-copyrighted, that met agreed-upon specifications. There is a possibility that demand for the bibliography could make such an enterprise not only self-supporting but even profitable.

6.3.4 A National Referral and Loan Network

Building comprehensive and up-to-date reference tools such as a national bibliography, union catalogs, and lists, and organizing work through such entities as regional libraries would make it possible to go a step further and create a national referral and loan network. A true network has not really been possible in the past, because of insufficient knowledge of the location of desired materials. With a machine-manipulated union catalog (or catalogs) and a properly designed communications network, requests could be routed automatically to the potential lenders. In addition, up-to-date corrections to the union catalog--possible because of the computer--could result in higher success ratios on interlibrary loan requests. With a sufficiently responsive configuration of equipment, procedures, and personnel, such a network would allow a library user anywhere in the country to obtain the materials he needs within a reasonable time.

The development of a National Referral and Loan Network would require about four years:

First year: Staffing, planning, design and coordination.

Second year: Initial operations; begin use of communications links to expedite handling of reference questions and loan requests.

Third year: Expanded operations, with initial, selective use of telefacsimile from region to region and full copying and mail or delivery service within regions.

Fourth year: Completion of network; telefacsimile would be available to all key points in the U.S., with copying and delivery available to any library. There would be full-scale reference, referral and interlibrary loan service available from any library in the network.

6.3.5 A National Library Storage and Microform Depository System

Physical deterioration of many kinds of library materials is recognized to be a nationwide problem. This project would establish a system of regional centers, supported by advanced technology, to house and preserve rarely used materials and provide loan copies or microform facsimiles to other libraries, as needed. The centers could also pursue research toward more effective preservation, with continuous study to determine what materials could be preserved and/or reproduced via microform. Such a program would diminish the storage requirements of local libraries and ensure that access to all documents is preserved.

The development of a National Library Storage and Microform Depository System would require about four years:

First year: Planning, staffing and preliminary design; designation of the regional centers.

Second year: Initial operations at the national center to preserve, restore, store, microfilm, reproduce, and loan selected printed materials.

Third year: Beginning of operations at the regional centers. By this time the national center and the regional centers would be interchanging microforms, and a national inventory record would be maintained at the national center.

Fourth year: Extension of the system into full operations.

6.4 SUPPORTING RESEARCH, DEVELOPMENT AND TRAINING

The five high-impact projects described in Section 6.3 are oriented toward operations. While they are dependent on technology and while they involve subsystems that will eventually be important in more extensive, integrated, and technology-dependent national networks, they do not contribute directly to the exploitation of technology by individual libraries.

The major barriers to the more extensive use of advanced technology in individual libraries are lack of funds, lack of personnel with the experience necessary to select and use some of the new technology, and--not least of all--the limitations of some of the technology for library purposes. As noted earlier, much of the extant technology has been developed without any particular consideration for potential library applications. The library "market" as such has been regarded by many manufacturers and developers of equipment and techniques as small, compared to the market toward which they direct most of their efforts. This has meant that libraries have often had to make do with what has been produced for very different purposes. Although there have been instances (e.g., in the MEDLARS system) in which special devices and techniques were developed for a library or library-like application, more devices, products, and techniques developed specifically for libraries are needed if future operational requirements of libraries, library systems, and library networks are to be met.

This report recommends that concurrent with the operations-oriented projects outlined above a program of technology-oriented library research, development, and training be undertaken. The identification of specific developments needed for library improvement should be based on a much more thorough study than this report attempts. However, examples are given below of areas where progress should undoubtedly be accelerated.

6.4.1 Hardware Specification and Development

The kinds of hardware of most potential interest to libraries include computers, communications equipment, microform-handling equipment, and other materials-handling equipment.

a. Computer Equipment. Several needs exist to make computer technology more compatible with library needs. Among these are:

  (1) Library-Oriented Input/Output Computer Equipment. Present equipment is not capable of handling the large character sets needed by libraries, and lacks the speed to deal with the large amounts of input/output needed to process the very large files typical in libraries. Line printers having 200 or more characters (about twice the currently available number), with little or no speed penalty, are needed. The need still continues, too, for optical scanners that are capable of reading a variety of fonts. Although an increasing number of publications will be produced by use of computer-driven printers, some new material, as well as the large mass of earlier material in the libraries, will not be available in machine-readable form.

  (2) Computer Consoles. Most consoles available today for man-computer interaction were produced for other than library needs. Most of the more flexible consoles are too expensive for all but a few applications, and they cannot readily handle the character sets needed for libraries. Consoles are needed that are better tailored to library use.

(3) Computer Memories. The large computer stores presently available were developed for applications whose storage requirements are small and speed requirements large, compared to those of library applications. Continued work is needed to develop large (10^{13} bits) storage capacity. Further work is also needed toward the development of associative memories and other techniques to reduce the amount of time required for searches in main memory.

b. Microform Equipment. Good equipment for creating microforms has been available for some years, and reasonably good equipment is also available for reading some forms of microcopy. Yet no really superior equipment, particularly for reading, is available off the shelf. Some equipment, acknowledged to be superior to current equipment for library purposes, is no longer even available. An accelerated development effort is needed to build the best products possible, so that microforms of all types may be used with comfort over extended periods of time.

c. Materials Handling. One of the major tasks in the library is materials handing, i.e., routing, transporting and delivering, books and other materials. Better and more economical devices are needed to improve the library's materials handling (i.e., shelving and distribution) capability, without seriously impairing the ability of library users to browse.

d. Communications Equipment. Equipment is needed to connect various libraries in such a way that, functionally, the user at any library can be provided with a catalog for the whole system and can obtain copies of material anywhere in the system. The communication network must combine the low cost of operation suited to the individual library's budget with the high speed of operation suited to the user's attention span.

While it may be appropriate to subsidize specific prototype hardware developments directly, another promising approach may be to attempt to "focus" the market by developing a consensus among libraries regarding their requirements and the kinds of devices that would meet them. With a clearer picture of desirable equipment specifications and of the market, a number of manufacturers could be expected to engage in developmental work without any need for direct subsidy.

6.4.2 Procedural (Software) Specification and Development

The identification of specific processing techniques worth developmental support should rest on a very careful analysis of projected library requirements in relation to the current state of the art. Some tools worth considering in such an analysis are listed below. Optimally, there should be concurrent hardware and software advances to achieve more effective processing techniques.

a. Organization and Search of Large Files. New approaches to computer organization and search in large memories are needed. Existing techniques are expensive, consume excessive amounts of time and memory, and cannot be easily adapted to library applications. Generalized retrieval systems suitable for libraries (i.e., capable of performing searches rapidly on a large volume of material) must be developed if the benefits of automated information systems are to filter down to the users. Such systems will need to be able to incorporate user feedback into the search process. This will require a combination of improved hardware and expanded software capabilities.

b. Library-Oriented Filing and Sorting. Today's computer sorting schemes are not capable of processing the large, special character sets required in libraries adequately, nor can they manipulate the large sort keys needed to sort library files effectively. Much more development along these lines is needed.

c. Utilization of Publication Output for Automated Text Processing. An ever-increasing amount of machine-readable information is becoming available as a byproduct of publishing today's literature. Techniques need to be developed for the efficient capture, storage, and subsequent use of this information for libraries.

d. Automated Subject Heading Assignment. Textual materials require accurate assignment to subject categories such as are used in traditional library catalogs. Skilled catalogers are in short supply, and even the most skilled human does not do equally well with all materials. An effort should be made to develop inexpensive and reliable automated (or machine-aided) systems that would allow some of the cataloging load to be assumed by machine processes. Such items as authority files, special cataloging thesauri, etc., appear to be particularly suitable to machine manipulation, and certain subject heading assignments could also be performed by machine accurately, consistently, and economically.

e. Time-Shared Processing Techniques. Many medium- and large-sized libraries are currently using or planning automated techniques for selected aspects of their internal operations. The emergence of networks will demand even more attention to automated techniques and particularly to time sharing on computers. Many problems of scheduling, allocation and communication need to be studied, preferably in operational contexts, if time sharing is to be used effectively in library networks. Special time-shared processing techniques suitable for smaller libraries are also needed so that these libraries will not be excluded from use of computer technology because of the high cost of developing and operating an individual system.

6.4.3 A Test Bed for Handling Nonbook Materials

The handling, representation, storage, and use of nonprinted materials have long presented problems to libraries, because practices appropriate to books have not been ideal for these other materials. With the continuing emergence of new media for information transfer, such as video tapes and magnetic recordings of several kinds, these problems will increase. It would be desirable to establish a facility that could serve as a test bed for the development of new methods and techniques for storing and processing these materials and making them accessible and usable. The facility could also serve as a demonstration or model library and could thus play a role in disseminating information about the new techniques.

6.4.4 Direct Supporting Research

The history of library technology, and particularly the current history of projects introducing automation into library functions, has uncovered one point so repeatedly that it is almost a truism. This is that technological artifacts such as punched cards, computers, data-link lines, computer programs, consoles, character readers, programming languages, television channels, large core memories, and the like, do not in and of themselves represent the actual solution of information problems. Rather, they constitute a necessary technological framework through which the solution to information problems may be pursued.

Without the facilitating technology, no amount of understanding of information flow, transmission and usage could result in sophisticated library or information systems. By the same token, no amount of sophistication, efficiency and economy of hardware and software components will result in effective information systems unless the necessary knowledge is available to orient the activities of these tools to the actual processes and functions the system is intended to serve. The purpose of direct supporting research is to provide such knowledge as soon as possible.

By direct supporting research is meant studies displaying two characteristics: (1) the goals of the study can be clearly stated and are directly aimed at contributing to the solution of one or more of the immediate problem areas for library and information system design, and (2) the study is organized and conducted in such a way as to provide generalizable knowledge rather than parochially oriented facts. There are at least three major areas of direct supporting research that should receive immediate and continuing attention:

a. Information characterization. The world of facts and ideas continues to change, accompanied by changes in man's responses to the facts and ideas, along with changes in his ways of characterizing or communicating about these things. Much more, for example, needs to be understood about the basic processes of analyzing and communicating information requirements, if the potentials of new equipment technology are to be exploited. Intensive studies are also needed of conceptual behaviors that form the bases of different classificatory schemes. A vast improvement needs to be achieved in our understanding of the manner in which situational and contextual constraints alter the conceptual and classificatory responses made to textual materials by librarians, information specialists, and users. A much better level of knowledge is required of the capacities and limitations for conceptual adaptability of a typical individual attempting to use an information characterization scheme that is somewhat foreign to him.

b. Evaluation tools and methodologies. The mechanism of progress consists of iteratively comparing two or more alternative paths or solutions and of selecting the better one. Therefore the method of comparison itself becomes of crucial importance in determining whether, in fact, progress will be made. Better, more precise, economical, and meaningful tools are needed for comparing and diagnosing existing procedural options, systems, and services. More sensitive and subtle procedures are needed for uncovering the merits, defects, utilities and penalties of various kinds of information media and channels, such as textual and audiovisual ones, so that each can be employed to its maximum advantage in libraries and library networks.

c. Effects of information. The services provided by libraries and other information facilities are based on a number of premises regarding the amount and kind of information their users want. Findings from some surveys that most of the material in libraries is not used much, if at all, raise questions about the adequacy of these premises and about the mechanisms libraries employ for staying attuned to the interests of their users. There is a need to develop a better understanding of the generation of new information and concepts,

> and its applications to the world of action. Better understanding of these phenomena appears to be a prerequisite to the development of more effective and efficient library systems, particularly in the selection of materials and in determining what level of access they should have. It would also appear to be very important in learning how to design effective interfaces for the man-machine transactions that occur in request formulations made to automated retrieval systems.

Research in these and related areas is, of course, already going on, with the support of various agencies of the Federal Government and through private organizations such as the Council on Library Resources. However, both the amount and range of directly relevant library work supported by these agencies are limited and need to be expanded.

6.4.5 Education and Training

A limiting factor in the exploitation of technology is the ability and preparation of library personnel to appraise and use technology. The need to improve the readiness of library personnel to use applicable technologies effectively has been recognized in the library schools and has led to intensive studies for curriculum improvement. Agencies of the Federal Government have also concerned themselves with this problem. This report endorses such attention and encourages its continuation.

It is important that attention be given both to formal training and on-the-job training. On-the-job training is important because the administrative and technical personnel already on the job are the ones who will be confronted soon with decisions regarding new equipment, techniques, and approaches particularly relating to participation in network operations. However, remedial education and training will not be enough. It is hoped that current efforts to improve library science and information science curricula, including post-graduate work, will continue to be encouraged and supported, not only by the Federal Government but by the library community itself.

Scholarships and fellowships have been made available in some subject fields to attract a wider variety of people into training. Librarianship has had relatively few students from scientific and technical subject majors. An expanded program of scholarships and fellowships would help to change this pattern.

Library schools themselves are not known for their affluent quarters and equipment. Vast improvement is needed in physical facilities, especially in terms of laboratory facilities for teaching and research with respect to technology. For example, remote-access consoles could be used to expose students to computer techniques; model installations of materials-handling equipment could demonstrate the problems of moving library materials by automated means.

A four-year program is recommended along these lines:

First year: Detailed planning for all aspects of training program; preparation of new curricular material; public announcements of scholarships, etc., and selection of first-year recipients.

Second year: Awards to selected schools for improving physical plant and laboratory facilities; preliminary new curricular material available; expanded scholarship and fellowship programs.

Third year: Physical plant and laboratory facilities improvement 90% accomplished; additional new curricular materials available; continued grant-in-aid programs.

Fourth year: Completed capital improvement program; full-scale evaluation study of new curriculum; other programs continued.

6.5 ORGANIZATION FOR ACTION

6.5.1 Basic Recommendations

Sections 6.3 and 6.4 have identified a number of activities that we believe would help to foster the effective use of technology in the service of U.S. libraries. Before such activities can be undertaken, several things must be done. They are listed here in the form of recommendations:

1. THE BASIC APPROACH OF USING HIGH-IMPACT PROJECTS, TOGETHER WITH SUPPORTING RESEARCH, DEVELOPMENT, EDUCATION AND TRAINING, SHOULD BE EXAMINED AND, IF POSSIBLE, ENDORSED AS THE MEANS BY WHICH LIBRARY IMPROVEMENT WILL BE SOUGHT DURING THE NEXT FIVE TO TEN YEARS.

2. THE PARTICULAR HIGH-IMPACT PROJECTS AND R&D REQUIREMENTS OUTLINED IN THIS REPORT SHOULD BE EXAMINED BY THE COMMISSION AND BY OTHER INTERESTED MEMBERS OF THE LIBRARY AND INFORMATION SCIENCE COMMUNITY, IN THE LIGHT OF OTHER ISSUES, REQUIREMENTS, AND CONSTRAINTS, TO DETERMINE WHAT PRIORITIES THESE AND OTHER POSSIBLE PROJECTS SHOULD BE ASSIGNED AT THIS TIME.

3. FOR THOSE PROJECTS SELECTED FOR IMPLEMENTATION, ARRANGEMENTS SHOULD BE MADE TO DEVELOP MORE DETAILED OBJECTIVES, TOGETHER WITH PRELIMINARY COST APPRAISALS AND IMPLEMENTATION SCHEDULES.

4. FOR THOSE PROJECTS SELECTED FOR IMPLEMENTATION, ARRANGEMENTS SHOULD BE MADE TO IDENTIFY ALL POTENTIAL SOURCES OF SUPPORT AND, AT THE APPROPRIATE TIME, OBTAIN THE FUNDS NECESSARY TO CARRY OUT THE PROJECTS AND PROGRAMS SELECTED.

5. RESPONSIBILITY FOR MANAGING THE CONDUCT OF THE ACTIVITIES INDICATED OR IMPLICIT IN THE FOREGOING RECOMMENDATIONS SHOULD BE PLACED AT A HIGH ADMINISTRATIVE LEVEL IN AN EXISTING OR NEW AGENCY OF THE FEDERAL GOVERNMENT OR IN A PUBLIC/PRIVATE BODY CREATED FOR THIS PURPOSE.

Recommendation 1 (Approach) is intended to assure that there is a common understanding of an agreement on the means by which the parties interested in library improvement intend to work toward it. It can provide a means for focusing the interests of the Federal Government, state and local governments, individual libraries, professional associations, manufacturers and suppliers of relevant equipment and services, and the public itself. We believe that the National Advisory Commission on Libraries is the appropriate body to appraise this recommendation.

Recommendation 2 (Project Selection) is intended to assure that the parties whose operations and services will be influenced by high-impact projects will have an opportunity to comment on and influence the final selection of such projects. One cannot expect to find unanimity in such an appraisal; nevertheless, one will be able to proceed with greater assurance and a better sense of priorities after such an appraisal. It seems highly desirable that the National Advisory Commission should initiate or arrange for the initiation of this appraisal in the context of its own report to the President.

Recommendation 3 (Project Definition) takes cognizance of the fact that the projects recommended in this report are described at a rather general level and that it will be necessary to develop more detailed specifications of objectives, of facilities and resources, of equipment and personnel costs, and of the time schedule under which development should proceed.

The descriptions given for the five network and systems projects (Section 6.3) and for the program of supporting research, development, and education and training (Section 6.4) may be used as points of departure for the detailed appraisal that must follow. Some very rough estimates of the costs for development and initial operations are offered in Figure 5 in order to provide an indication of the absolute and relative magnitudes of the projects as we envision them. The largest costs are for the library networks and systems projects, which are necessarily broad in scope and involve, in some instances, substantial expenditures for equipment and materials.

The cost figures are over and above present funding from all sources. Thus, the program could require 400 to 500 million dollars additional over the next five years for development and initial operations. No estimates are given for continuing costs, but they would presumably be less than those for the last year of each project's development and initial operations, particularly since the hardware required for some of those projects would already have been acquired.

PROJECT OR AREA	ADDITIONAL* COST BY YEAR (in millions of dollars)				
	First Year	Second Year	Third Year	Fourth Year	Fifth Year
Networks and Systems					
Prototype Network of Regional Libraries	3.0	36.0-44.0	55.0-75.0	80.0-120.0	? **
Expanded, Machine-Based National Union Catalog	1.5	10.0	8.0-12.0	?	?
National Bibliography	.5	2.5	?	?	?
National Referral and Loan Network	.5	2.0	5.0	10.0	?
National Library Storage and Microform Depository System	1.8	18.0-22.0	40.0-50.0	50.0-60.0	?
Research and Development					
Hardware Specification and Development	3.0	6.0	8.0	8.0	5.0
Procedural (Software) Specification and Development	3.0	4.0	5.0	4.0	4.0
Test Bed for Handling New Forms	.2	3.0	6.0	3.0	3.0
Direct Supporting Research	3.0	4.0	5.0	4.0	4.0
Education and Training	1.5	5.0	2.0	3.0	?

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*These are costs over and above present funding from all sources.

**Continuing costs.

Figure 5. Estimated Costs for Development and Initial Operations, Library Improvement Program

Recommendation 4 (Project Funding) takes note of the obvious fact that any accelerated action program will require extensive funds. It is almost equally evident that the Federal Government will be expected to provide most of those funds. As indicated earlier, there are many parties with legitimate and continuing interests in the future of libraries. All do not have equal power to effect change. Thus, for example, while most of the support for the libraries in the nation comes from local (tax) funds, the leverage of local libraries to effect system change is exceedingly small, compared to that of the Federal Government, because control of the funds is dispersed over so many localities. The difference in the power to effect change may help, in one sense, to ease the task of defining responsibilities for effecting change. What each party "ought" to do may become, in part, a function of what each party can do.

This does not mean that the Federal Government needs to carry the entire burden of funding, nor that it needs to bear the costs of continued operations, once the period of development and initial operations is over. Some of the programs, for example, the Expanded Union Catalog, could be self-supporting in a short time, perhaps almost from the outset.

Recommendation 5 (Program Management) recognizes that planning, starting and managing the action program outlined above will require a high degree of coordination and the involvement and support of the Federal Government. The body responsible for the planning and administration of the library improvement program needs to have high-level status and support.

It is obvious that the need for assessment and planning for libraries will not diminish or disappear once the present Commission presents its report; changes will continue to occur and new technologies will need to be assessed for their impact on current and planned library programs. To assure that effective planning and implementation continue, a permanent body is needed. Such a body would need to be responsible or make provisions for (1) keeping informed on the existing and prospective state of library service; (2) planning for improved library service at both national and local levels; (3) developing legislative proposals; (4) coordinating various projects affecting library service; and (5) planning and coordinating financial support, from both the public and private sectors. Such a body would require the participation of a variety of persons with diverse skills, experience, and points of view and should therefore include representation from the Federal, state and local governments, individual libraries, professional organizations, manufacturers and suppliers of relevant equipment and services, and the public itself. An organized group of this nature would be able to exercise the continued leadership needed for a concerted nationwide effort to improve library operations and services.

A number of possibilities suggest themselves for the permanent body, including the Library of Congress, some kind of independent organization--perhaps a public/private corporation--or the National Advisory Commission itself. The extension of the tenure of the National Advisory Commission on Libraries is particularly attractive in that it would help to insure continuity of thinking and planning and it would take full advantage of the interest, expertise and communication and working arrangements developed by the Commission during its year of intensive work. If this approach were followed, it would be important to make provisions for having high-level and diversified technical staff support on a full-time basis, even if this meant "borrowing" some key personnel from Government or private organizations for a period of a year or so.

6.5.2 The Need for Momentum and Continuity

Whatever the planning mechanism recommended by the Commission, it is important not to lose the impetus that will be provided by the Commission's work. Leaving a sizable and indeterminate time gap between the Commission's work and development and implementation of an action program would run the risk of fostering a paralysis of the will and a resulting inactivity or delay in undertaking needed improvements. It would also run the risk, particularly if much time passes without action, of inviting another status-type survey covering much the same ground as the present Commission has covered. Both technology and the needs for library service are certainly changing, but not so rapidly or erratically that they should encourage an endless succession of independent assessments, discontinuous in time and concept. The need for library improvement is clear, and so is the potential contribution of advanced technology. Action is now needed to assure that the problems of libraries are not relegated to the background of happenstance. An aggressive, concerted and timely effort, using modern technology and every other means that can be brought to bear, is needed to effect a nationwide improvement of our libraries.

APPENDIX A: COMPUTER TECHNOLOGY RELATED TO THE LIBRARY

A-1 COMPUTER SYSTEMS

Within a short span of 15 years, intensive development work has brought about truly amazing increases in capacity and decreases in cost for computer systems. An extremely wide range of computers and associated equipment is now available, with various configurations spanning a purchase range from $6,000 to $10,000,000.

This section briefly reviews the status of computer technology as related to library systems, highlights particularly important trends in such technology, and provides a prognostication of the state of the art in five to ten years.

A computer system consists of hardware (the equipment) and software (the programs and instructions). The earlier computers had much less hardware capability than those being marketed today, and with additional software, could perform many of the same tasks now being performed primarily by hardware. Supplying these capabilities in the form of hardware adds to the speed of operation and, thus, reduces the cost of operating the computer, though it raises initial costs of hardware.

The hardware of the computer consists of five segments (see Figure A-1):

Central Processing Units
Main Memories
Mass Memories
Peripheral (Input/Output) Devices
Terminal Devices

A-2 CENTRAL PROCESSING UNITS

The Central Processing Unit (CPU) is that portion of the computer complex that actually processes the information, e.g., performs computations, comparisons, etc. The amount of computational capability built into the CPU involves an engineering compromise between two alternatives: (1) giving the computer user something inexpensive, but requiring him to expend a large amount of effort to use it, and (2) providing him with a more complex and expensive machine that requires him to expend less effort to use it for those applications for which it is intended. Capabilities that are not built directly into the CPU must be provided by computer programs.

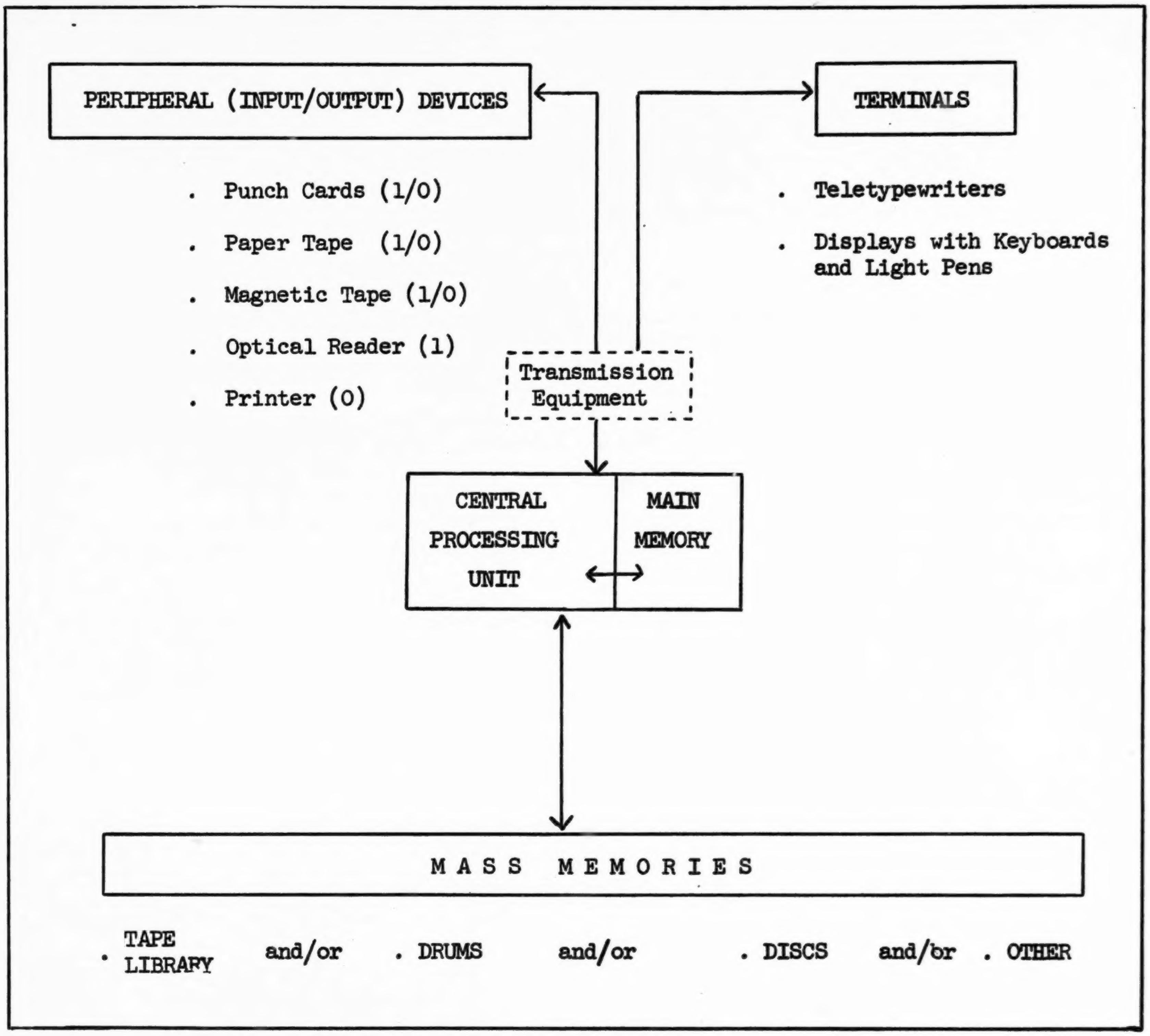
PERIPHERAL (INPUT/OUTPUT) DEVICES
. Punch Cards (1/0)
. Paper Tape (1/0)
. Magnetic Tape (1/0)
. Optical Reader (1)
. Printer (0)
TERMINALS
. Teletypewriters
. Displays with Keyboards and Light Pens
Transmission Equipment
CENTRAL PROCESSING UNIT
MAIN MEMORY
MASS MEMORIES
. TAPE LIBRARY
and/or
. DRUMS
and/or
. DISCS
and/or
. OTHER

Figure A-1. Main Components of a Computer System

Most CPUs have been built for problems of scientific computation or business data processing, rather than for problems of library automation. Nevertheless, these units are more than adequate to handle any of the problems of library data processing. The barriers that stand in the way of library automation are not technical inadequacy of the CPU, but price, lack of adequate software, too little peripheral memory capacity, or limitations in the input/output equipment.

In addition to being able to operate very rapidly, present-day CPUs have a number of features that make them more adaptable to library automation than their predecessors. A particularly important feature, increasingly common in today's CPUs, is the external interrupt capability. With this feature, external devices such as the teletypewriter can cause the central processor to suspend its operation momentarily to read a character, and then return to its previous operation. A multiplicity of terminals can thus be operated simultaneously in this fashion by a large number of persons, each using the computing capability and the data files of a centralized system in his own particular way. Such multiple use is known as "time-sharing."

Another important feature of present-day CPUs, necessary for time-sharing, is called memory protection. With this feature, each of the many simultaneous users can operate with the assurance that another user cannot alter, or even read, his program, if the latter is a consideration. This feature can be extended to protect data as well, and lends itself to systems that can operate with sensitive or classified information.

A-3 MAIN MEMORIES

Computer storage (memory) includes a wide range of storage media that differ in the relative speed and ease with which the CPU can obtain information from them. The fastest, most easily accessible, and most expensive storage is called main memory or internal memory.[1]

A large percentage of present-day main memories are made of arrays of magnetic cores. Within the past 15 years, with improvements in manufacturing techniques, core memories have increased in speed from a 10-microsecond cycle time for performing one operation to a 1-microsecond cycle time. During the same period, the cost has dropped from over $1 per bit to the present approximately 25¢ per bit, and it is not unreasonable to expect cost to decrease to only a penny a bit.[2] Since a typical large computer may have from one- to five-million bits of main memory, this is an important factor in the overall cost of the system.

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[1] "Memory" and "storage" are used interchangeably here.

[2] Bit stands for "binary digit," the elementary unit of information stored and processed by a computer. Ordinarily, six bits are required to represent one character or symbol, if the number of symbols is limited to 64.

It is doubtful that another order of magnitude in speed improvement will occur in core memories in the next decade. Other types of main memory devices are emerging, including thin films, integrated circuits, plated wire, laminated ferrites, cryogenic devices, and others. It is difficult to say which will be the most successful. Most of the newer types are more expensive than cores, but have a speed advantage. However, even today's internal storage is generally adequate for handling library problems.

A-4 MASS MEMORIES

Mass memory--or bulk storage devices--provide large stores of accessible data for computer systems. Present-day memories of this category include magnetic drums, discs, and various forms of magnetic tape. Some of these can store up to 10^{12} bits,[3] at a fraction of the cost of core memory storage. The penalty for this greater capacity and lower cost is time. Information generally has to be read from external storage into internal storage before it can be handled by the CPU. External storage requires milliseconds for access, rather than microseconds (as in the case of core memories).

A-4.1 MAGNETIC TAPES

Magnetic tapes are considered here as falling into the category of mass storage devices. However, their use as such is decreasing year by year as faster-access storage such as drums and discs becomes larger and cheaper. Magnetic tape was the first form of computer storage. It has many advantages, perhaps the foremost being that it is the least expensive of the many forms of storage. It is also easy to store; the only limit is that of space required to maintain the reels in a library-like stack. In addition, magnetic tape (as well as the punched card) has the virtue of almost universal readability by a multitude of different machines. Where readability is not directly possible, it is usually easy to translate from the form required by one machine to the form required by another.

The main disadvantage of magnetic tape is its relatively slow speed. Even if the tape is already mounted on one of the tape-handling devices associated with the computer, one has to wait for the tape wheels to rotate so that the desired portion of information is in position to be read by the computer.

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[3] This is the file size mentioned in the King report in connection with cataloging the information at the Library of Congress. It is the equivalent of 40,000 reels of magnetic tape, or 33 billion English words. (Hereafter storage capacities and costs will be discussed in terms of English words rather than bits. The arbitrary but reasonable rule will be followed that 30 bits = one word in binary form, not binary coded decimal.)

Up to five minutes may be required to pass from beginning to end of a tape. Often one must wait for location of the tape and manual placement of the tape on the machine. In spite of such limitations, magnetic tape is still considered so versatile that almost all computer systems provide for a number of tape drives. Thus, it is likely that magnetic tape will remain the major backup storage for the large amount of information that is required for library operation.

Present-day tapes have recording densities over 50 words per inch, and a typical 2400-foot tape can hold the equivalent of over one million English words. This data can be transferred at a rate of about 50,000 words per second. Both density and speed will probably double within ten years. The present cost of tape storage is only about .015 cents per word,[4] which is far cheaper than discs or drums. If the user can tolerate the relatively slow access time, which may be as high as several minutes, magnetic tape is the medium to use.

A-4.2 MAGNETIC DRUMS

Drum storage has been in use almost as long as tape storage. Magnetic drums were originally used as internal storage on the earlier computers and some inexpensive computers still use them.

Drum storage has the advantage of requiring a much smaller access time than tape. The fastest drums have an access time of less than .01 seconds and can transfer words at virtually the same rate as core memory. One generally never needs to wait longer than one drum revolution in order to get the data that are required.

Drum storage is, in one sense, a compromise between main memory storage and tape storage. Drum capacity (up to 333,000 words) is smaller than tape capacity, but greater than that of main memories. The access time is slower than main memories, but faster than tape. Storage cost is on the order of 3¢ per word, far less than core storage but greater than tape.

One deficiency that drum storage has in comparison to tape storage is that the device itself cannot be disconnected from the computer: drum storage stays with the computer and presumably has its information removed when the next problem or task is run. However, drums are seeing substantial use in time-sharing computers and will undoubtedly continue to be important for some time.

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[4] Evaluating the cost per bit of magnetic tape is difficult. One reel of magnetic tape costs only $25, but the tape drive and part of the controller must also be amortized, and the access time must be considered. If access is restricted to a mounted reel (resulting in an access time of several milliseconds to three or four minutes), one cost will be derived. If access time were five or six minutes, which would include mounting a reel, the apparent cost would drop by two or three orders of magnitude. The former case has been considered here.

A-4.3 MAGNETIC DISCS

Use of magnetic discs for storage came next in the development of computer storage media. The disc device looks somewhat like a jukebox, with many discs contained in a stack. The amount of time to get information from a disc is roughly the same as that for getting it from a drum, once the desired disc is accessed by a reading head. In general, discs have slower access than drums because one may have to wait for the reading head to be applied to the proper disc. (Some machines reduce this problem by having more than one reading head available.) Discs make a good compromise between drums and tapes, both in terms of capacity and speed. The cost for storage is roughly the same as that of drums (about 3¢ per word). It is unlikely that this cost will ever drop to that of magnetic tapes (.015¢ per word).

A recent development in discs gives them a much greater advantage over the original disc-like external storages. This is the development of the disc pack, which allows a small group of discs to be removed from the computer in the same way that a magnetic tape can be removed. Thus, the advantage of non-serial accessibility of the disc is married to the advantage of being able to remove discs when the machine is to be used for other purposes. In fact, many new computer systems have been sold without tape-handling capability at all, with total reliance on disc packs. The disc pack will be important for holding the generally changing data required for the operation of libraries.

A-4.4 OTHER MEMORY DEVICES

Other forms of mass memory are being developed or produced. One type that has the highest capacity, and lowest cost per stored word, is the "photoscopic" disc, which is a photographic, read-only memory. These devices, with capacities up to 33 billion words, could be generally available in the next few years at a cost of about .03 cents per word. Since they are not magnetic, updating a disc is a photocopying operation and takes longer than updating a magnetic drum or disc--minutes rather than seconds. However, photoscopic discs are ideally suited to operations involving a relatively stable kind of information, such as dictionaries or authority files that must be consulted frequently. Libraries have many such files.

Research and development are continuing on associative, or "content-addressable," memories. If economical associative memories could be developed, they would have important applications in libraries, where the retrieval of entries could be based on coincidence of a part of an input or query pattern with a part of the stored reference patterns. Associative memories are still in the laboratory stage, and it seems unlikely that adequately large ones will be available within the next five to ten years.

A-5 PERIPHERAL (INPUT/OUTPUT) DEVICES

A-5.1 PUNCHED CARDS

The punched card--a popular storage medium in the pre-computer era of electric accounting machinery--continues to be the main input for some kinds of data. It has some advantages over other types of input which may never be overcome. One of the chief ones is that a small portion of a program or set of data may be added, deleted, or changed conveniently.

On the other hand, punched card equipment is extremely slow for input and output to a computer. Thus, it is inadequate for handling large quantities of data. In addition, most punched-card equipment provides for only 64 characters. This tends to suppress the type of information that is carried by different type fonts in libraries. The distinction between upper case and lower case is usually lost. Some punched-card machines will handle larger character sets, but these are generally available only on special order.

A-5.2 PAPER TAPE

Paper tape has long been used in communications and has found good use as a cheap input/output medium in computer systems. Many of the smaller computers have used this as the prime means for entering programs. Punched paper tape *overcomes some of the drawbacks* of the punched card. It is usually created on a typewriter-like device and can represent the full set of characters found on typewriters. The ease of keyboarding and of inputting paper tape to the machine is comparable to that of punched cards, and on output, one gets typescript with the full range of typewriter characters.

Paper tape readers and punches can be associated with (and even interchanged with) teletypewriter keyboard-printer devices. They are able to transmit messages rapidly and accurately, and they can store messages and send them on request of the computers to which they are attached. Use of paper tape as an input device will probably increase as time-sharing terminals become more prevalent.

Paper tape output is quite slow, because it is character-by-character, rather than card-by-card (as with punched cards) or line-by-line (as with computer line-printer). It is fragile, compared to cards, and also relatively difficult to search. Since it is a serial medium, one may have to scan the entire tape, character by character, to find a particular item. In this respect, it is much less satisfactory than a properly arranged file of punched cards.

A-5.3 MAGNETIC TAPE

Magnetic tape has been referred to above as a form of external storage for the computer. It also lends itself naturally to being an input/output medium. Since the early 1950's, there have been devices for keyboarding information directly onto magnetic tape. Such devices are as easy to use as punched paper tape for purposes of input. In addition, magnetic tape has been the natural form of output from computers for many years. Some high-speed printing devices work directly from magnetic tape. High-speed typesetting is possible from magnetic tape, e.g., devices produced by Photon, Mergenthaler, etc.

A-5.4 OTHER INPUT/OUTPUT DEVICES

Another class of input/output equipment includes the typewriter or typewriter-like devices. These are discussed in Section A-6, Terminal Devices, since they are particularly adaptable to an on-line mode of operation.

A-5.5 OPTICAL READERS

Optical readers are rather specialized computer input devices, intended primarily for preparing massive amounts of text for computer processing.

Many of the speculations on future library automation involve the assumption that there would be a computer-readable version of the text of documents. Since early language-processing research required little text, most researchers were content to have material keypunched for the computer, at about 1 cent per English word. This would be very expensive, of course, for large-scale conversion of library holdings. Calculations showed that few, if any, of the developments in large-scale information processing would reach the point of economic feasibility unless a much less expensive technique was discovered for putting already printed text into computer-readable form. This conclusion led to the development of the optical reader, or, as it is sometime called, the optical scanner.

Optical readers scan pages of print and write what has been read onto magnetic tape, punched cards, or directly into the computer memory. Current readers have widely varying capabilities and prices. Some that sense marks (not characters) cost about $20,000. Others that can sense a variety of fonts, and even a limited amount of handwriting, cost from $200,000 to $500,000.

Considerable progress is being made in optical scanner technology. Ten years ago the only fonts that could be read were highly stylized and, although readable by people, unnatural in appearance. Later advances allowed optical character readers to read a few typewriter fonts, and at present some character readers can read several fonts, printed or typed, with high speed, accuracy, and economy, provided there is unsmudged text on clean paper, properly placed. Although there are predictions that in ten years almost any document will be readable by machine, general-purpose text readers will probably not be available that soon.

The optical scanning technique is useful as a substitute for keypunching, and it will probably be more so for libraries or other organizations that either have a sufficient volume of suitably prepared information to be able to afford their own optical character reader, or can conveniently send the material to a service bureau. Keyboarding could be done on ordinary typewriters (with a standardized typeset) by people trained as typists, instead of being done on more expensive punched-card, paper-tape, or magnetic-tape equipment. It is unlikely, however, that it will be useful or economical to libraries as a technique for reading the bulk of present holdings, even if that were desirable.[5]

A-5.6 HIGH-SPEED PRINTERS

The high-speed line printer is the usual means of printing output from a computer. Such printers operate at over 1200 lines per minute, each line of which can be over 130 characters wide. The quality of print turned out by high-speed printers is usually poorer than that produced by typewriters, and it is considerably poorer than the quality of any formally printed material. In part, this lack of quality stems from the fact that most printers are only equipped to turn out upper-case letters, numerals, and a few special characters. Printers with both upper- and lower-case letters have become available, but all of them are somewhat slower than the equivalent standard upper-case only printers.

A-6 TERMINAL DEVICES

The previous section was concerned with input/output equipment used in an "off-line" manner. In the off-line approach to the use of the computer, human interaction with the machine is foregone in order not to slow it down waiting for the much slower-reacting human. The devices discussed here are intended for use in situations where the man and the machine interact in "real time." Since the matter of data transmission is closely related to the use of terminals, it will be touched on briefly, even though it is primarily the concern of other commissioned reports.

For many years now, there has been interest in providing techniques for human interaction with the computer while it is operating. Current techniques attempt to preserve some element of the computer's great speed by having many persons coupled to the computer at the same time. Two general classes of equipment are currently being used. One is the relatively inexpensive typewriter-like device. The other is the much more expensive and sophisticated console with a cathode ray tube.

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[5] The ideal situation is one in which keyboarding is done only once for any given item. Since the publisher of a book or report must keyboard it, it would be a great convenience to have a machine-readable output of that keyboarding. Even without machine-readable tapes or optical readers, a few libraries are attempting to make one keyboarding serve several purposes, e.g., order preparation, in-process lists, catalog and production, circulation control, etc.

A-6.1 TYPEWRITER-LIKE DEVICES

The most commonly used terminals are keyboard devices, e.g., typewriters. The input rate depends on the user's skill, which is well within the 14.8 characters per second allowed by the transmission line. Output is likewise limited, but there are lines that allow transmission at more than 14.8 c.p.s. In that case, output speed is limited by the terminal, which is commonly about 10 characters per second (approximately 100 words per minute), although there are special terminals that will accept about 20 characters per second.

There are a variety of modems (modulator-demodulators) available for coupling teletypewriter terminals to telephone lines. The most common are those provided by the telephone companies themselves. Another device, which has come into popularity within the last year, is the audiocoupler. This permits the connection of a teletypewriter to a computer via telephone. The main advantage of this technique is that the device is portable. It is not yet as reliable, however, as a permanent connection via data set (input/output interfaces between telephone lines and the computer or terminal). The pushbutton on a touch-tone telephone is also seeing some use for input to a computer.

Terminals may be connected to a computer either by leased line or by a dial-up service. With a leased line, the connection is always available and the quality of transmission is likely to be somewhat better. The dial-up service is more economical, unless the terminal has a very high usage factor. For example, a leased line across the country for a teletype would cost about $3000 per month. A dial-up service would have to be used over 100 hours a month to cost an equivalent amount.

One of the advantages of typewriter-type equipment is that it is relatively inexpensive. The cheapest send-receive teletypewriter (Model 33) can be purchased for $470, a price that is not likely to change drastically in the next few years. Other keyboard-type terminals (not common-carrier) cost up to $3000. Another advantage is that typewriter-like devices require little training in their use. Also, they can be located thousands of miles or even a continent away from the computer. The low-capacity lines needed to use the teletype have already been installed for other (commercial) reasons. The primary disadvantages have to do with output. Speed is limited because of the mechanical slowness of a one-stroke-at-a-time device, and the variety of output is restricted to those characters found on typewriters or teletypewriters.

A-6.2 CATHODE-RAY-TUBE (CRT) CONSOLES

The next most common type of man-machine interactive terminal is the cathode-ray-tube (CRT) display console. CRTs can be divided into two categories, based on vastly different prices and capabilities.

The cheaper CRTs are relatively small devices--about the size of a 14-inch TV--with an alphanumeric keyboard and perhaps some other control buttons. The keyboards function much the same as typewriter keyboards, providing direct input to the computer or causing a character to be displayed on the face of the CRT, or both. Some consoles have considerable editing capability, permitting a message to be composed and displayed, enlarged, shortened, altered, rearranged, etc., before it is transmitted to the computer.

The display usually allows only alphanumeric characters, but some of the terminals have a limited graphic capability, permitting the display of bar charts and the like. A typical number of displayed characters is 1000 per display controller. Each controller can drive a number of CRTs, and the 1000 characters are divided equally among the consoles. The quality of the image is poorer than the printed quality received through a teletypewriter. One compensation for this reduction of quality is the fact that a full screen of print can be placed in front of the user almost instantaneously.

Most of these consoles are made to operate remotely from the central computer, but at each remote site a display controller device is required. Since these controllers are made to drive a number of terminals, the cost of any isolated terminal must also include a controller. Considering a system where controllers are adequately utilized, this class of display console (with its amortized share of the controller) costs about $6000 to $7000.

Much work is being done on the development of cheaper CRT terminals, and by the end of the next decade they should be down to the price of a commercial TV set. Another approach in reducing the cost of a CRT terminal is the development of a communication method whereby the display controller can be centrally located, or the development of a practical storage tube that does not require continuous transmission of data (as does TV).

Present-day communication links for display consoles of this type can use telephone lines of voice-grade quality. Here again, a variety of data sets are available. The most popular of these are products of the common carriers. Private lines having an adequate bandwidth (e.g., send 300-400 characters per second) cost about twice as much as telegraph lines. Dial-up service closely approximates that of telegraph (teletype), i.e., a transmission speed of 14.8 characters per second. While these speeds are likely to increase they will not approach the speeds of dedicated lines.

The more sophisticated consoles in the second group cost from $25,000 to $200,000 apiece. These devices have larger tubes (19 to 23 inches); can present more data; have curve-drawing and other graphic capabilities, and have light pens that can be used as switches (triggered by displayed data) or as pens for drawing curves on the CRT, plus numerous other characteristics. Some of the more elaborate display consoles have the capability of mixing computer-generated data with rear-projected slide or film-strip images. These may even be in color.

No attempt to locate these consoles remotely from the computer has been made, except experimentally. Effective use of this kind of console requires a high rate of information transfer between console and computer, and common practice has been to limit the distance to one or two thousand feet. For longer distances, microwave links or video cables--with their inherently high costs--must be used to provide connection lines with sufficient bandwidth. An alternative is to use a small peripheral processor at the remote site and communicate between processors with a slower and less expensive channel (2 KC may well be adequate).

A-6.3 OTHER KINDS OF TERMINALS

Another type of output terminal that has seen some limited use and has shown promise for application is the audio response unit. Designs range from devices that store a limited number of words to those that synthesize output messages from a stored vocabularly of words, or even synthesize words from stored phonemes. (This latter device is not commercially available.) A typical device can hold over 60 individual message segments of 1.6 seconds duration. This is probably inadequate to synthesize the variety of messages most library systems might require. Another audio response device has a vocabulary of 127 words; still another provides for a large vocabulary to be stored in "digitally coded voice." The latter system requires a million bits to store 750 words. Both of these devices are quite expensive--in the $30,000 to $50,000 range.

One manufacturer has developed a family of equipment that permits converting pictures to digital data and transmitting them to a computer. The reverse process is also possible, i.e., synthesizing a picture from digital data transmitted from a computer. The major advantage of this system is the speed with which it operates. It will, for example, allow transmission of printed material in 8-point or larger type at a rate of about 10 quarto pages per minute. Without involving the computer, the device could convert, transmit, and reproduce text at an acceptable rate over a moderately priced transmission line, such as Telpak A.

APPENDIX B: PROCEDURAL TECHNOLOGY RELATED TO THE LIBRARY

B-1 INTRODUCTION

There are a number of applications of data processing equipment that are much more dependent on the solution of conceptual problems than on hardware. We will refer to this group of applications as "procedural technology," to distinguish them from the kinds of technology discussed in Appendices A and C. It is important to note that even though the equipment and procedural technologies are necessarily interrelated, they do not necessarily develop at the same rate.

Most of the procedural technologies discussed in this appendix are computer-oriented, although a great many manual and mechanical techniques are also utilized to make specific library operations more efficient. Some of these are discussed in Section 4 and in Appendix C. They include photographic systems of various types, as well as edge-notched, punched-card and "peek-a-boo" card systems. All have their place in library technology. However, it seems fairly clear that computer technology has greater potential for the immediate as well as for the more remote future of libraries.

Each of the technologies discussed in this section is considered to have some degree of potential applicability to library systems. The objective of this appendix is to define and discuss each procedure in sufficient detail to indicate the bases for statements and conjectures made in the main body of the report. As will become apparent, the various procedures discussed are interrelated; the distinctions implied by the separate headings in this appendix are for convenience of presentation.

B-2 DOCUMENT STORAGE AND RETRIEVAL

B-2.1 DEFINITION AND PURPOSE

Document storage and retrieval is concerned with methods for organizing and managing collections of documents (recorded information) to facilitate their recovery as they are needed. Defined in this general way, document retrieval is hard to distinguish in principle from the kind of activity that libraries have performed for centuries. (It also shares many aspects of business record keeping.) What distinguishes the field from more conventional library operations is the reliance upon mechanical and electronic aids and associated procedural technology.[1]

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[1] The term "information storage and retrieval," originally introduced to describe the kinds of activity we are discussing, is ambiguous and does not help to distinguish between retrieving a document or document citation and retrieving information or data contained somewhere within the document.

The terms "data management" or "data retrieval" are often used to refer to storage and retrieval operations in which the records are not documents but more discrete, often numerical, items. Invariably, such data are stored in highly structured and formatted files for ease of handling. This is not usually the case in document files, which consist of variable-length records with different kinds of textual data. Inventory records and stock market quotations are examples of data files. Success in processing such highly organized files antedates and still outdistances achievements in document handling. There are differences as well as significant similarities in the processing techniques used in both of these activities. However, in this discussion, document storage and retrieval systems, rather than data retrieval systems, will be the main concern.

A few specialized techniques that are closely related to the problems of document storage and retrieval (such as automated indexing and automated classification) are discussed separately below for purposes of emphasis and clarity (see Sections B-3 through B-6).

B-2.2 STATE OF THE ART

Systems designed for purposes of document storage and retrieval include several key processes: (1) analyzing of incoming material to create some representation that may be stored in the file; (2) storing the material and its representation in appropriate files and arranging for their later manipulation, as needed; (3) analyzing of information requests and converting them into a search prescription; and (4) searching the file to match the prescription against the stored data, to provide "relevant" responses. Some document storage and retrieval systems--particularly those tailored to handle standing requests for various kinds of information--are referred to as "selective dissemination" systems. Conceptually, selective dissemination is a service that can be performed by any comprehensive document storage and retrieval system, and should be considered as an integral part of such a system rather than a separate entity.

The state of the art in each of the four basic processes listed above is sufficiently different to warrant a separate discussion for each.

B-2.2.1 Document Analysis and Representation

Operational information systems, even those with a very high degree of automation, do not presently use computers for analyzing and preparing representations of documents. This is because it has not yet proved possible to build into computer programs all of the kinds of considerations that human document analysts and indexers bring to their decisions. Although there has been nearly a decade of interest and work in automatic indexing, abstracting, and classification for providing representations of documents, there is not yet a satisfactory capability of identifying automatically those aspects of a document that need to be preserved in the representation.

A basic technical problem is that all analysis and representation involves a subtle and often unconscious process of comparison with other documents being processed or already in the store, or with previously expressed user needs. No adequate means have yet been developed to provide such information to the computer system.

Despite this problem, a degree of success has been achieved with relatively simple tools such as permutation indexes, in which individual key terms in a document title are automatically alphabetized by the computer and the terms, plus title context, listed as an aid to document search. This level of representation has not proved adequate to meet the search needs in most document storage and retrieval systems, since the index consists only of words actually used in the title, and there are no vocabulary controls.

Another technique in which something like automatic representation can be done is the so-called "full-text indexing," in which the computer makes a concordance of all of the "content" terms in a document and their location in the text. Such systems are already technically feasible for the production of concordances. They can be useful in those instances where one can afford to store full text in a computer and where one requires the capability to search on the basis of any term mentioned in the text. There are few, if any, installations in existence where full-text indexing is in operational use.

Although automated data processing techniques can be used to provide a number of valuable aids for document analysis and for the preparation of representations, at present such functions still remain in the province of the skilled librarian.

B-2.2.2 Storage and Manipulation

Document systems are concerned with two kinds of storage files--those that store the document itself, and those that store the document representation. These two files may be kept separate or merged; most systems keep them separate. Some document storage and retrieval systems maintain a microform file of their holdings, but this is not for processing by the computer itself.

In no operational system is the full text of all the documents in the collection stored in the computer for search and retrieval, because (1) it would be expensive and time-consuming to code all this information; (2) graphs and photographs would be very difficult to code; (3) computer storage facilities are expensive and limited--even magnetic tape files would not be large or cheap enough; and (4) most importantly, such full text storage is of unproven value for operational systems.

One potential advantage of having the full text of a document available in machine-readable form for computer processing is that an automated analysis of the document could be made and representations of the document could be prepared. However, as was pointed out, automated document analysis is still in the research stage. On the other hand, considerable progress has been made in using the computer to manipulate more limited sets of representation data, such as accession numbers, titles, authors, citations, etc. Such document representations can be sorted, reordered, restructured, displayed, and otherwise processed in many ways, depending on the capabilities built into the particular computer program. Although there is a great deal of current activity and discussion on file organization and data management, most of it is focused on questions of the economics and efficiency of particular techniques, or on the best means to take advantage of changing hardware capabilities. In this vein, one area currently receiving attention is that of generalized data management systems, i.e., computer programs and procedures that permit one to create, merge, or restructure new and existing files within an existing programming system without extensive reprogramming. Most data management systems have not been mainly concerned with the manipulation of natural language text or unformatted data, but there is a trend toward consideration of text-processing and editing features for such systems.

The primary advantages of generalized data management systems are that: (1) the same basic programming system can be used by any of several information facilities (for example, libraries), with each facility using only those aspects of the program that address its particular requirements; and (2) any given facility can modify its processing procedures without needing to rebuild an entirely new, special-purpose program. The primary disadvantage of such generalized systems is that they are larger and more complex than special-purpose programs and therefore less efficient and more costly to operate on the computer. Operational efficiency is traded for general utility. To date, the applications to library problems have generally been of this generalized type and, therefore, have been less efficient for this specific application than if a specialized program had been written for each application.

B-2.2.3 Requests Analysis

Like the analysis of documents, the analysis of information requests is largely a human activity in most document storage and retrieval facilities. The user generally provides some kind of description of the kinds of information he is seeking; sometimes a reference librarian or information specialist must review the request, perhaps in consultation with the user, and convert it into a set of terms that he thinks will be most likely to retrieve documents relevant to the user's needs. The task of automation here is to convert written requests into an effective set of search terms without the help of a human intermediary. This has not been achieved yet in an operational system. However, the automation of this area may be less difficult than document analysis, if for no other reason than that information requests are much shorter and therefore require much less condensation and conversion to provide suitable search avenues to a file.

One type of arrangement that promises to be fairly successful is to have the user communicate his information needs directly to the computer via an input typewriter console. At present, such arrangements constrain users to communicate in specific "authorized" subsets of English. However, promising research is under way to provide better computer "understanding" of less restrictive subsets (e.g., natural English) or to permit an interactive "negotiation" or "interpretation" of the query. The latter efforts are still in the research stage, and have not yet provided tools for operational use.[2]

B-2.2.4 File Searching

The manner in which a file is searched is highly dependent on both its original mode of organization and the kind and configuration of storage media available. Here, the procedural and equipment technologies are very closely interrelated.

There are two basic file organization strategies that can be used in document storage and retrieval systems: the unit record file and the inverted file. In the unit file, each document record (e.g., citation, index terms, and, perhaps, abstract) maintains its integrity. The standard library catalog card is an example of the unit file.

Until the development of the coordinate indexing system, most libraries used a set of unit cards, such as LC cards, for main and added entries, including subject headings. In the card catalog the unit subject heading cards are usually arranged by authors for the subsets of each subject.

In contrast to the unit cards, with classification numbers (call numbers) as well as all the descriptive information and tracings on each card, coordinate indexing cards are simply subject term cards with only document accession numbers posted on them. They are called inverted cards and their files are referred to as inverted files. This system was developed for report literature and journal articles. Separate files are maintained for other indexes to the document collection, e.g., author index and source index.

Both unit-card and inverted-card files can be used for computer storage and retrieval. Each system has its own advantages and disadvantages. The unit record file system must add approximately five new records (filed by author(s), title and subject(s)) for each new document added to the collection. The inverted file grows much more slowly, since only the new document numbers need to be posted on existing records. A new record needs to be created only when a new index term is authorized. However, the other indexes to the inverted file continue to grow.

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[2] Some already operational systems allow the user to specify search terms, on line, to the computer. These systems are not considered to involve request analysis, in the literal sense.

Recent studies have shown that for automated retrieval systems based on magnetic tape as the storage medium, the use of an inverted file may hinder rather than enhance retrieval, and further, the index itself must be constantly updated, thus making maintenance operations more complex. Also, more time is required to purge the file or modify terms applied to an entry.

When one moves to more rapidly accessible storage media that are not limited to sequential access (e.g., discs, drums, and core memory), the difficulties with the inverted file are substantially reduced. How, precisely, to take best advantage of rapid-access storage media for more efficient search is currently the object of considerable interest and work, with several techniques of file organization, data addressing, and data association vying for favor. The best conclusion that one may draw at this point is that many alternative techniques of file organization and search are available for a particular installation, and the primary questions are those of efficiency, not capability.

The most difficult search problem, from the standpoint of systems that deal with documents, is to locate relevant information in the computer file having a description that is different from that expressed in the query. This problem is, of course, exactly the same for manual systems as it is for computer-based systems. However, the computer has been demonstrated to offer some special capabilities for dealing with this problem. For instance, one can develop and store a fairly large thesaurus and/or authority list in a computer file so that translations can be made automatically between the query and the contents of the file. Thus, a single term used by a requestor (or the librarian) can be expanded into a set of related terms to enhance the likelihood of covering relevant material. Should some of the terms used in the query not be authorized index terms in the particular system's vocabulary, the computer can--in many instances--make the translation to legitimate terms automatically. Such capabilities are already in operational use, and more powerful capabilities are well within range.

B-2.3 FUTURE DEVELOPMENTS AND APPLICATIONS

In the next five to ten years, we may expect to see substantial, continued improvement in techniques for document storage and retrieval, quite apart from the advances in equipment technology and linguistic knowledge on which (in part) they ultimately depend. There will almost certainly be acceptably efficient computer aids to human indexing and classification, using machine-readable inputs that are provided by optical readers or that are by-products of publication. Techniques of file organization and search, currently lagging behind equipment technology, will probably keep up reasonably well with the increasing demands placed on them by the very large files that new equipment techniques are providing. Too, the present somewhat embryonic techniques for direct interaction with the file--already accepted in the intelligence community and increasingly mentioned in "libraries of the future" discussions--can be expected to become relatively commonplace in research-type libraries that can afford some degree of computer assistance.

Although many technical problems must be overcome to make substantial improvements in document storage and retrieval techniques, the most serious problems may be those of cost rather than those of technical feasibility. Thus, the widespread applicability of document storage and retrieval techniques is heavily dependent on the degree to which success is achieved in providing cheaper and more powerful computer equipment (see Appendix A for details on computer technology).

B-3 AUTOMATED CLASSIFICATION

B-3.1 DEFINITION AND PURPOSE

Most libraries in the United States use some kind of classification system (either the Library of Congress or the Dewey Decimal scheme). The basic purpose of such systems is to group together textual objects that are conceptually related.

The purpose of automated classification techniques is to use computers to subdivide a mass of materials into organized groups, to improve the efficiency of searching. There are two aspects to automated classification: (1) defining the groups that constitute the classification scheme and (2) assigning materials to particular groups.

B-3.2 CURRENT STATUS

The basic objective of current research and development in automated classification is to optimize the grouping of documents for computer-based storage and retrieval and to assign each document to its proper group or groups by using programs that substitute computer manipulation--in whole or in part--for human judgment. A secondary, but nevertheless important, objective is to have the capability to detect changes in the character of the collection (automatically) and, accordingly, to modify and update the classification scheme and the document assignments.

Thus far, studies have shown that computers can be used to generate classification categories that look reasonable and that have a moderate amount of agreement with categories created by human classifiers on the same material. Studies have also shown a moderate amount of agreement between human and computer sorting of documents into prescribed categories. (It must be remembered that humans show only a moderate amount of agreement with each other on such tasks.)

A basic procedure commonly employed in generating an automated classification scheme is to compare a list of words or word pairs from (or representing) each document with a similar list from every other document in a collection, and to use various mathematical and statistical sorting techniques to construct a number of categories that encompass the full range of material and yet permit a reasonable subdivision. The second step, classifying documents into the previously determined categories, is accomplished by preparing a list of "clue words" which best distinguish each category from all others, and then comparing each document against the various clue-word lists for best fit.

Research to date has identified a number of problems that must be solved before automated classification can be accepted as a useful adjunct, much less as a serious competitor to conventional classification systems:

1. A problem inherent in any classification method based upon the words used in the document is that there is not a one-to-one correspondence between the exact words in the document and what the document is about, or in what it is saying about the subject matter. Whereas humans can see the same "concept" in many alternative sets of words, present automated classification techniques are closely tied to the particular words the documents happen to use. Providing the computer with an adequate repertoire of word-concept translations may not be impossible, but it is difficult and has not yet been demonstrated.

2. A second problem is that there are many different ways of conceiving of, and measuring, document similarity. Each has proponents, but an intelligent choice cannot be made until evaluation criteria are better developed.

3. A third problem has to do with the size of the document collection that can be automatically classified. Most experiments have used only a small data base of a few hundred documents. There is now some indication that the data base can be enlarged, but this still has to be demonstrated in practice.

4. A fourth problem has to do with the depth of indexing required to provide inputs to automated classification. The 15 to 30 descriptors ordinarily required exceed by far the number

applied to documents in operational systems. Unless automated indexing has preceded the automated classification, the costs for the latter might be too large for practicality.

5. A fifth problem has to do with computer costs. Comparison of each document with every other document, for purposes of generating classification schemes, involves large amounts of computation. As the number of documents to be processed increases, computation time and dollar cost increase geometrically, thus making the classification of large numbers of documents quite impractical. Some recent breakthroughs in processing strategy offer promise of shifting the cost from an exponential to a linear increase. Using these new algorithms, generating a classification system for 10,000 documents would require approximately 20 minutes on a modern high-speed computer and would cost around $250. Thus, automated classification is no longer entirely ruled out--on the grounds of cost--for some kinds of automated libraries and information facilities.

6. Finally, there is the problem that no generally accepted methods have yet been developed to evaluate the products of automated classification efforts or to indicate whether one method gives "better" results than the other. While there are promising research leads in this direction it is worth noting that there have been few systematic attempts to evaluate, or to compare, various manual classification systems such as LC, Dewey, or UDC on an operational, as opposed to a theoretical, basis.

Because of these kinds of problems, use of computer-generated classification schemes is not yet appropriate for most libraries or even for most semi-automated retrieval systems. In addition to the fact that the relative merits of automated classification are yet to be demonstrated, there is the fact that all libraries presently use one or more existing "conventional" classification systems, and their personnel and patrons would require extensive training to reorient themselves toward computer-generated, adaptive classification systems. The cost of data generation and programming is also, for the moment, a prohibitive factor. For the present, exploratory use of computer-derived classification categories is desirable primarily where documents are already deeply indexed, and where either the existing schedule is not considered satisfactory or there is no classification schedule at all, e.g., with:

- specialized collections of current technical reports on the leading edge of science and technology,
- specialized collections of current technical reports being produced by a particular organization,

- specialized collections of information whose basic character is constantly changing so that new trends need to be identified and the organization of the data modified,
- accumulations of documents by individual researchers or small projects for their specialized, and often temporary, needs.

On the other hand, use of computers to place documents into classification categories that have already been established is not nearly so far off. Given a set of human or machine-derived terms representing what a document is "about," computer techniques may--in the next two or three years--prove adept at assigning the documents to appropriate classification categories. If the current classification assignments are regarded as correct--i.e., as an acceptable criterion--for evaluating computer assignments, a year or two of experimentation should make it clear whether an acceptable level of accuracy can be developed for the computer

B-3.3 FUTURE DEVELOPMENTS AND POTENTIAL

The need for all forms of automated text-processing techniques, including automated classification, will increase as collections grow and as more materials become available in machine-readable form. Regardless of the fact that costs per unit of computer input and processing are dropping each year, it will continue to be inefficient and wasteful to search complete files where there is the possibility of subdividing the file and searching within a small set of documents or document representations. In addition, it seems likely that progress will continue to be made in solving the technical problems mentioned above.

The status and value of automated classification are sufficiently uncertain to make predictions of use hazardous. It seems very unlikely that automatically generated classification schemes will supplant existing ones. They may find some use as an adjunct to established schedules, perhaps helping the library staff to notice possible new perspectives and providing alternative paths for the users to "browse." On the whole, the best prediction one can make at the moment is that computer-generated schemes will be used infrequently and primarily as a means of sensitizing the system periodically to changes in the character of the collection. Obviously, this use will be more prevelant in new or rapidly changing collections, of the sort presently found in information centers, rather than in conventional libraries.

Looking ahead to 1975, one may expect to see some large libraries regularly developing or receiving machine-readable data on some percentage of their inputs, and using automatic classification techniques to "suggest" assignments to the human classifiers. This kind of a joint, man-machine document assignment may have considerable promise. While the detailed "analysis" performed by the computer may help humans notice new concepts or relationships, present text-processing techniques do not, and perhaps cannot ever, use all of the information "context" that a human brings to the classification situation. Thus, the idea of man-machine cooperation offers interesting possibilities for classification. A moderate amount of research attention to this possibility might permit use of even present-day automated classification programs.

B-4 AUTOMATED INDEXING

B-4.1 DEFINITION AND PURPOSE

The term "automated indexing" refers to several different computer-based procedures, all of which share the feature of providing some means of subject access by a searcher to particular documents. The simplest kind of automated indexing is that done in connection with document titles. The most complex kind attempts either to extract appropriate index terms from documents, or uses the words in the document as a basis for assigning still other, more appropriate index terms.

B-4.2 CURRENT STATUS

Most of the interest in automated indexing has been in connection with technical information systems, rather than libraries. This is largely because such systems are oriented toward information retrieval, a function that relatively few libraries emphasize. However, some--and perhaps all--automated indexing techniques have strong potential for library operations.

Although there is still controversy about the relative merits of automatically produced indexes of titles,[3] compared with subject indexes prepared by humans, there is little doubt that title indexes are already useful search tools, and no doubt whatever that they are relatively inexpensive to produce. A list of 4,000 titles, for example, requires approximately 50 minutes on a large modern computer to be converted into a KWIC-type index. Including time for keypunching or other preparation, and given an existing program (of which there are many), total costs for such an index are under $1,500. Computer costs for these indexes go up in roughly linear fashion with the number of titles. Current research on KWIC-type indexes is concerned with refinements of the technique, with extension to non-title material, and with questions of effectiveness. The effectiveness of KWIC indexes is heavily dependent on the adequacy of the titles themselves; accordingly, pressure is growing for authors to use representative, rather than fanciful, titles.

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[3] The most commonly used is referred to as a KWIC (Key Word In Context) Index.

The automatic selection or assignment of index terms from text, originally viewed with optimism some years ago, is increasingly recognized to be a difficult challenge. Early hopes that individual content words used with high frequency in a document would identify adequately what the document is "about" have given way to recognition that high-quality indexing is concept indexing, and at the very least, needs to consider syntactic and semantic factors, i.e., both the order and the context of words. Many current studies are attempting to meet or circumvent this problem.

While fully automatic indexing is a desirable goal, it does not yet seem within reach, a fact which has led to increasing interest in computer-aided indexing, i.e., a man-machine cooperation in indexing. A current example is the use of a computer to select candidate indexing terms from the text of a book, and to organize these by frequency of occurrence (i.e., into a permutation-type index) so that the final selection can be made by a trained indexer. This is a classic and important example of using a computer to perform a task for which it is eminently suited, while still taking full advantage of special human capabilities in making the final selection.

Other important uses being explored for computer-aided indexing are those in which a computer acts as clerk-verifier-editor-monitor of human indexing activity and as a recorder of such activity data as requests sought under a given term, the number of times users enter the system with a term not in a glossary, etc. Such activity data can be an invaluable guide in the design (by humans) of a consistent, user-oriented indexing language. Full capability to provide such useful aids to human indexing is already well within the current status and requires only some developmental activity to be readily available. However, the economic value of providing computer-produced aids to indexing has not yet been demonstrated. Studies are needed to compare the unit cost and quality of indexing when using completely manual and computer-aided indexing procedures.

B-4.3 FUTURE DEVELOPMENTS AND POTENTIAL

The permutation technique, already firmly established and widely used, could be very useful for quite a number of library operations. For example, in acquisitions, one of the biggest drawbacks to a conventional file of outstanding orders is that there is only one entry per item. Both staff and patrons, in seeking to find what is on order in a library, often ask for a particular item by other than the entry that has been used in the order file. A KWIC-type index of the order file could be most useful here, particularly for monographic series or for volumes of conference proceedings with multiple authorship or sponsorship.

Within three to five years, one may expect to see widespread use of computer aids to indexing in most information facilities that have access to a computer. Many of the uses will be of the "monitoring" variety that help system personnel to be aware both of their own linguistic practices and those of their clientele. Computer programs for such monitoring are relatively small, simple and inexpensive; the bookkeeping is done "behind the scene," and a printed output may be required only at infrequent intervals.

Policy changes in technical journals, particularly in the engineering field, require more authors to suggest a set of index terms at the time they submit their articles for publication. These terms may be printed along with the article, with or without modifications. If this policy becomes more prevalent (and there is every indication that it will), the task of the journal indexers will shift in emphasis from the selection or assignment of terms to the more intellectually demanding task of insuring quality. If this occurs, the role of automatically producing indexing aids (computer-suggested index terms similar to author-suggested index terms) may become increasingly important.

Within the same period, one may also expect to see some information systems in which index terms are either "suggested" or directly supplied through computer analysis of text. (This is, of course, economical only in those instances where the text has already been prepared in machine-readable form as a by-product of some operation, e.g., publication.) Although present-day index term extraction does not appear to compete in quality with the best human indexing, expected advancements in the understanding of language and of human indexing itself seem very likely to support a gradual but steady increase in the acceptability of computer-selected index terms. Given a parallel growth of machine-supported thesauri and authority lists, one can foresee, by 1975, a number of systems--particularly specialized technical information systems--that will rely heavily on the assignment of index terms from automated analysis of text, with a final review by a supervising indexer.

Book indexing can also be done prior to publication. Library of Congress catalog card numbers are already assigned in this manner, and the concept could be expanded to include subject indexing performed as a service for the benefit of all libraries. Indexing and cataloging of books is not likely to be affected in the near future by automated indexing, for such indexing is shallow and would not benefit greatly from a computer analysis of the entire text.

B-5 MACHINE TRANSLATION AND AUTOMATED ABSTRACTING

B-5.1 DEFINITION AND PURPOSE

Machine translation, or MT as it is commonly called, aims to use computer processing to translate texts from one language into another in order to make the contents of foreign-language documents more accessible and usable. Automated abstracting, as the name implies, attempts to prepare condensed representations of documents by computer processing rather than by human analysis. These topics are treated together because they involve processing of the full text of documents and the use of statistical, syntactic and semantic tools.

B-5.2 CURRENT STATUS

Although work in MT started out optimistically several years ago, the analysis of language has proved to be much more difficult and complex than was anticipated. While machine translation of sorts can be accomplished by using a large internally stored dictionary and largely word-by-word techniques, the results achieved by this method are, for the most part, not very satisfactory, either in terms of readability or in terms of accuracy. The acknowledged disappointments in practical applications have helped to shift emphasis from translation per se to basic research in linguistics.

The current status in automated abstracting has undergone almost no change for the past several years. After an enthusiastic start in the early 1960's, most of the effort has come to a halt because of severe and discouraging conceptual and technical problems. The basic premise on which automated abstracting work was founded is that certain parts of documents--usually sentence units--carried the essence of the total document message and that, by using statistical techniques based on word frequencies, one could identify these sentences and assemble them into an abstract. Early work floundered somewhat on the same problems of comparative evaluation experienced in automated indexing and automatic classification. It was also discovered that statistical cues alone were not sufficiently powerful to select all the "best" sentences, a finding that led to efforts to prescribe good "clue" words to be up-weighted, other words to be down-weighted, and additional nonstatistical criteria (e.g., the position of the sentence in the document) for sentence selection.

Quite apart from whether or not the "best" sentences were located for the abstract, there is the additional problem of automatically organizing them into a coherent piece of prose. Since there has not been, and does not yet exist, a capability for the reliable generation of contextually meaningful sentences, current automated abstracting techniques can only string together sentences extracted from the text. While there was some degree of acceptance (or tolerance) shown for such rough-reading products in experimental applications where the need for current awareness overrode the demand for elegance of expression, even here there has been a gradual erosion of acceptance. No relief for this particular problem is in sight at the present time.

Producing an automated abstract of a journal article, given a machine-readable record, would require roughly one-half minute of computer time on a large, modern computer and would cost about $4.00 in a batch-processing operation. This figure assumes that no sentence-generating capability is necessary.

B-5.3 FUTURE DEVELOPMENT AND POTENTIAL OF AUTOMATED ABSTRACTING

The future of automated abstracting is highly problematical. Any increments of improvement, at our present state of knowledge about language and language processing, can be expected to be very small. Any substantial progress in automated abstracting must await a breakthrough in other language-processing techniques, particularly in understanding sentence "context" and concepts that are expressed by groups of sentences but are not *in* any particular sentence. Furthermore, since some technical journals, as well as elements of the Department of Defense, are requiring that an author-produced abstract be submitted along with the article, the need for an automated abstracting capability may be diminishing.

Looking ahead to 1975, any substantial *independent* progress in automated abstracting that would make the use of those techniques attractive to most libraries cannot be foreseen. Although the required breakthrough could conceivably come, it does not seem prudent to count on it, particularly since abstracts do not now play, nor do they seem likely to play, an extensive role in most library operations.

A similarly gloomy prognosis must be made for fully automated translation. Significant advances will have to be made in computational linguistics before the quality of either MT or automated abstracting can be improved to the extent of achieving general acceptance.

B-6 QUESTION-ANSWERING SYSTEMS: RETRIEVAL OF INFORMATION

B-6.1 DEFINITION AND PURPOSE

Up to this point, consideration has been given to document storage and retrieval systems and those aspects of automated language processing that are related to the storage and retrieval of documents and their representations. From some users' point of view, the ultimate retrieval system is one in which they ask questions and receive answers--not documents. Automated question-answering systems are designed to provide this kind of service.

B-6.2 CURRENT STATUS

Question-answering systems are of particular interest to libraries, inasmuch as they provide a rather direct analogy to the reference situation. The basic approach is to store the reference material in the computer, search through it in response to a question, and output an "answer," i.e., a very small amount of highly relevant data.

The degree to which question-answering systems can be considered already an accomplished fact depends on one's definition. If one has highly structured *data*, such as are contained in airline schedules or census material, and if one asks questions in a prescribed and simple format (e.g., "fare, Chicago/ New York"), question-answering is a fait accompli and has been so for several years. If, on the other hand, the file contains text, and if the user is allowed to express his question in ordinary English and expects a well-formulated answer, then fully automatic question-answering is a distant goal.

There is one kind of system, already being used in an experimental way, that combines the question-answering approach with ordinary reference retrieval, i.e., providing the user with references rather than answers. The system simply takes the "content" terms in the question as subject descriptors and performs a search accordingly. The questions are not "screened" or formalized, as they are in a typical reference retrieval system such as MEDLARS. The system does not have the capability for "understanding" the question in a semantic sense.

The reasons for this are much the same as those for machine translation. For a computer (or, indeed, for a human) to deal with language in a way comparable to the expectable range of human understanding, a great deal of information is needed--information about the grammatical structure of the question and the text, about the meanings of words in the particular context, and about the world. Knowledge that humans take for granted (e.g., San Francisco is a city in the United States) needs to be deliberately programmed into a question-answering system in order to get a reasonable response. While research progress is being made in providing all three of these kinds of information (syntactic, semantic, and real-world) to computer systems, it is becoming apparent that high-quality natural language question-answering from usefully broad content domains is subject to as many difficulties as fully automated mechanical translation and may be as many years away. However, there are a number of researchers working at such systems, and this should help to accelerate progress.

Question-answering systems could prove to be a very valuable aid and support for the reference librarian. Considering today's technology, and the machine's limited capability to "understand" questions, such systems would operate best when used by reference personnel rather than by the library patrons. The latter might have such a limited knowledge of the file and such a variety of question-asking expressions that it would be impossible for any current question-answering system to interpret them adequately. However, reference personnel who were cognizant of the file and the acceptable question format might make good use of machine-readable files.

On the other hand, there is the knotty problem of deciding which material to store in machine-readable files. The sizable costs of preparing and storing any significant amount of textual material or a sizable "data base" in a computer, together with the infrequency of questions on any given material, make it unthinkable for a typical library to have all of its reference material in computer form. For the present, question-answering technology is most realistically considered in terms of a system in which many libraries are sharing not only the computer time but the reference material (including cost of storage) as well.

B-6.3 FUTURE DEVELOPMENTS AND POTENTIAL

Although automated question-answering, in the most elegant sense, is probably technically more difficult than machine translation, we may expect, by 1975, to see a great many instances of its use. Both the desire and the capability for communicating with the computer in natural language will continue to grow. With steady improvements based on linguistic research and experience from current embryonic question-answering systems, one may expect to find some level of question-answering capability in many reference facilities. Even if many of the expected technical improvements in question-answering systems do not materialize, there will still be many such systems in operation, because computer support will be increasingly inexpensive and accessible; less-than-elegant systems will provide some useful service; and a new generation of librarians, information specialists and patrons in technical libraries will have learned, to some extent, how to communicate with computer-based systems.

B-7 COMPUTER-AIDED INSTRUCTION

B-7.1 DEFINITION AND PURPOSE

The term "computer-aided instruction" (CAI) refers to a number of techniques for using computers to assist in communicating information to learners. While these techniques were originally developed in an educational context, they are now seen to have a broader applicability than was first recognized. CAI techniques are presently being developed as instructional adjuncts to computer-based systems with other than an educational purpose.

B-7.2 CURRENT STATUS

The feasibility of using a computer as a teaching machine was first explored around 1959. Since that time, a number of computer-aided instructional systems have been developed, most of them experimental but a few of them in operational use. Equipment at terminals for students often includes typewriters, random-access film projection devices and, less typically, cathode-ray-tube display devices. Equipment has recently been shown that can display rear-projected slides on the face of a cathode ray tube, thus eliminating the requirement for all CRT display material to be computer-stored. Equipment and techniques for audio response and interaction are not nearly as far along. Random-access tape recorders are in general use, but they are not as efficient as workers would like. There is some research underway to have the computer "recognize" speech and to generate speech, either by using prerecorded words or phrases or by using a set of rules to convert stored speech sounds into meaningful speech patterns. Such systems already exist, for example at the New York Stock Exchange.

Three major problems barring widespread use of CAI are currently commanding attention. The first is the technical, or equipment problem. While computer system capabilities are generally quite adequate for today's needs, computers need to become more reliable, particularly for on-line operations where "down time" is a nuisance, in addition to being costly. Improvements are also necessary in computer programming for time-shared systems (the only kind of system that permits several persons to use the system simultaneously).

The second major problem involves semantics. It is concerned with the precision with which desired meaning can be conveyed between the learner and the system. Thus, one must decide whether to use, for any given communication, an audio or visual mode, and when and how to switch from one to the other or to use both of them simultaneously (redundantly). One must also learn how to prepare and program instructional material that makes some concessions to individual differences among learners without being unacceptably expensive. Preparing such material is presently slow and costly; a single two-hour lesson may take several months to prepare. Of course, once prepared, such a lesson can be widely used.

The third problem has to do with effectiveness. To date, studies on the effectiveness of various aspects of CAI are somewhat inconclusive, in part because adequate evaluation criteria and methods have not been devised yet, and in part because the effectiveness of CAI appears to be very situation-dependent. Thus, valid generalizations are difficult to make.

Because of a lack of reliable information on effectiveness, it is not fruitful to discuss questions of CAI cost/effectiveness at this time. It has repeatedly been remarked that the present costs of CAI are prohibitive for all uses except research. However, this need not necessarily be the case, where either (1) the CAI is an adjunct to an operational system that does a highly related job (e.g., acquisitions control or circulation), or (2) where CAI shares the machine with some other unrelated function such as payroll or cost accounting.

B-7.3 FUTURE DEVELOPMENTS AND POTENTIAL

Granted an increasing use of computers in libraries, both for technical processes and for reference services, CAI can play an important role. On-the-job training of new library personnel, both professional and clerical, is a demanding task that all libraries face periodically and most face continually. By adding instructional components to the computer programs used for various aspects of technical processes, the library can shift *some* of the teaching burden from experienced library personnel (already in short supply) to the computer. CAI can also be useful in helping library patrons to learn how to use the particular library's resources or to conduct some kinds of reference searches.

By 1975, one may expect to see a large number of CAI-type facilities in many libraries, particularly those in an educational or research setting. The "library college" concept, which attempts to shift emphasis in college libraries from archival functions toward direct education, is a forerunner of what is likely to be an increasingly accepted concept of service. In line with this concept, some colleges and universities are already planning or building study carrels equipped with input/output equipment for more direct contact between the student and the information store. Unless library personnel are to add a sizable training load to their regular library duties, they must--and undoubtedly will--take advantage of the opportunity for the system to help students learn how to use the library more effectively.

Within a very few years, one may expect to see CAI-type programs developed in connection with most operational programs for support to technical processes in libraries. For many people, the most desirable and effective method of learning how to deal with a computer-based system is to sit down at the console and learn by doing. CAI-type programs can bring some measure of efficiency to this process and help to avoid both unnecessary frustration from blind fumbling or excessive dependence on experienced library personnel. By 1975, it will probably be rare to find any significant degree of computer support without also finding a CAI element as an adjunct.

APPENDIX C: RELATED EQUIPMENT AND MATERIALS TECHNOLOGY

C-1 INTRODUCTION

This section describes several kinds of equipment, materials and techniques, other than those primarily associated with computers, that bear on library operations, present or future. Topics discussed are: Microform Technology, Reprography, Publication Techniques, Physical Handling and Storage, Transmission of Materials, and Lasers and Holograms. The status of each of these is briefly described, together with possible applications.

For some materials, equipment or techniques, there is general information available on costs; where this is so, it has been provided to suggest orders of magnitude. It should be understood that these general figures will not necessarily apply to particular equipment operated in particular circumstances. In some instances, meaningful cost information is not available, or was not readily available at the time of this report.

C-2 MICROFORM TECHNOLOGY

C-2.1 PRESENT STATUS

Microforms come in many sizes and shapes. They are available both as microreductions on opaque sheets, enlarged for viewing by reflection, and as transparent films through which light is passed into an enlarging mechanism. Microfilm is available both in rolls and in individual sheets. Until quite recently, the roll form has been prevalent in libraries and in newspaper operations. However, unit record sheet film, referred to as microfiche, or simply fiche, has been receiving increasing attention and emphasis as the most effective microform for reports and as potentially the most valuable form to replace paper copies of bound volumes.

During the past decade, the use of microforms has undergone another radical change. Initially, microfilming was thought of as a technique for space reduction in some special libraries or in connection with the need for preservation of materials in scholarly libraries. This was true both for files that were going to be stored away for safekeeping and for the preservation of much more fragile documents, such as newspapers. However, microforms are now beginning to be used as a medium of communication, much as books and report literature are used.

The widespread use of microfiche has coincided with the beginning of a new library concept within the Federal Government--that of a distributing, rather than a circulating, library or information facility. Documents are not to be returned; they are to be kept or discarded. Such a concept is quite practical with microforms. The Defense Documentation Center, NASA, and the Federal Clearinghouse for Scientific and Technical Information are currently distributing reports in fiche forms, and the U.S. Office of Education has announced its intention to make fiche available on material of interest to those concerned with educational resources. The cost savings in fiche are apparent from the fact that the Clearinghouse sells a hard copy document for $3.00 and can sell a fiche for 65¢. The price holds, whether the document can be contained on only one fiche or requires six, seven, or eight for example. The U.S. Office of Education intends to distribute fiche at 9¢ each.[1]

The microfiche standards created by the Federal government through COSATI (the Committee on Scientific and Technical Information) have gone a long way towards eliminating the earlier confusion and incompatibility that resulted from having many forms. The fiche produced under these standards are 4 x 6 inches, with a 19:1 reduction ratio. The initial sheet (or fiche) of each document has title, author, and other such information on the top edge of the fiche printed in a size enabling it to be read by the unaided eye. The remainder of the fiche consists of 5 rows, each representing 12 document pages. If additional fiche are needed in order to represent the full document--as they are for nearly any book--the succeeding sheets contain 6 rows of 12 pages, rather than 5 rows. Thus, considerable reduction is achieved without losing the capability of handling individual documents as units.

With the production and distribution of information in microform, it was necessary to create usable, inexpensive microform readers. It is now possible to obtain good desk top readers for microfiche for under $100, roughly the price of a portable typewriter. Thus, it no longer need be housed only in the library; one can easily have a reader in one's office. Better readers are, of course, available at higher prices, extending past $1000. The more expensive of the readers provide the capability of producing hard copy and provide a means for libraries to either circulate or distribute copies. The fiche remains with the library, while hard copy or a second fiche is produced to be carried away. There is some question as to whether using even the most expensive current readers is as acceptable as viewing hard copy, when one has to read for many hours of the day. However, their convenience and other advantages override some of their limitations.

At present, the film handling in most microfilm filing systems is done manually. Most files are not of sufficient volume to warrant automated or semi-automated mechanized handling. Only during the past few years have manufacturers directed product research and development efforts in this area, because some microfilm files are becoming quite large. Microfiche edge-sensing by mechanical or magnetic processes is used for quick retrieval of a single fiche and also subsequent transport to readers, cameras, or reproducers. The Houston Fearless CARD system also automatically selects the desired image on the selected fiche through the use of X-Y coordinates. Roll film has retained its importance in those areas where the size of the document greatly exceeds the capacity of a single fiche, e.g., parts catalogs. In addition, if a portion of film is to be chosen by some means other than visual examination, then roll film provides an easier mechanical procedure for reaching the paper frame on the film. Several devices exist for searching reels mechanically and retrieving via motorized transports. Use of roll film in cartridge form will probably increase, for a period, in special library applications. However, it seems probable that within the next five to ten years, the dominant microform for library applications will be the microfiche sheet.

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[1] This price is unofficial and subject to change. Also note that it does not represent "cost" to USOE, but only "selling price" to the recipient.

Within the past two years, much effort has been devoted to developing color microfilm. The primary difficulty has been the low resolution qualities of existing color film as compared to black and white film. For many applications, color must be precise, and present color film is inconsistent in color rendition. In addition, it fades, even in controlled conditions, and because of its construction, is very sensitive to scratching, surface damage from handling and dirt, and loss of color images from the layering of color gelatins.

Since color microfilm is just coming out of research into development, there is presently little in the way of processing equipment for duplicating microfilms or for printing from the color film. However, automatic processing equipment exists now for mass-production handling of color films; microfilming equipment for black and white film can usually handle color film; viewing devices usually have color-corrected lenses; and printing equipment often can reproduce the color image in black and white. Microfilm costs vary widely in different organizations and in different parts of the U.S. A summary of current average costs is presented in Figure 6.

C-2.2 FUTURE DEVELOPMENTS

With a predictable large increase in the use of microforms, we may expect to see significant improvements in microform technology over the next ten years, both in the materials available and in the equipment for processing and storing it. Most of the needed improvements may not require any technological breakthrough. For example, although increasingly large sizes of microfilm files demands more sophisticated microfilm-handling hardware, this will probably come through concentrated product engineering that utilizes the principles of existing electronic and mechanical developments. This type of development effort, along with procedural breakthroughs in computer-based information retrieval, can lead to more and better computer-controlled systems that can automatically manage large-scale microfiche and/or microfilm reel files.

	COST IN $*		Reduct. Ratio	#/FICHE		# of Images per Unit	COST PER IMAGE		STORAGE REQ./100,000 PAGES		
	Orig. Microfilm	Dupe. Microfilm		Rows	Cols.		Orig.	Dupe.	Units of Microform	Linear Inches for Units	Linear Inches for Orig.
Black & White											
A. Roll Film						(100' roll)			(# reels)		
1. 35mm Roll-Normal	22.00	6.50	16x	--	--	550	.040	.0118	180	360	1200
Hi Density	72.00	6.50	16x	--	--	1,800	.040	.0042	56	112	1200
2. 16mm Rotary	60.00	6.00	24x	--	--	2,400	.025	.0025	42	84	1200
Planetary	100.00	6.00	24x	--	--	2,400	.042	.0025	42	84	1200
B. Fiche						(per fiche)			(# fiche)		
1. COSATI	1.75	.12	19x	5	12	60	.029	.0020	1,670	16.7	1200
2. NMA	2.10	.12	24x	6	14	84	.025	.0020	1,190	11.9	1200
3. Library STD	7.50	.12	50x	13	30	390	.019	.0003	256	2.6	1200
4. HR-1	300.00	1.00	120x	30	70	2,100	.143	.0005	48	0.5	1200
5. HR-2	300.00	1.00	150x	40	80	3,200	.094	.0003	32	0.3	1200
Color											
A. Roll Film											
1. 35mm	85-125	75.00	16x	--	--	550	.254 - .227	.136			
2. 16mm	125-150	40.00	24x	--	--	2,400	.057 - .063	.017			
B. Fiche											
1. COSATI	7.50	5.00	19x	5	12	60	.125	.0830			
2. NMA	10.50	5.00	24x	6	14	84	.125	.0590			
3. Library STD	48.75	5.00	50x	13	30	390	.125	.0128			
C. Aperture Card											
1. 35mm	0.357	0.357	16x	2	2	4	.089	.089			
2. 16mm	0.193	0.193	24x	2	4	8	.024	.024			

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*Includes labor, film, and processing.

Figure 6. Microfilm Cost Comparisons

We can also expect to see increasing development of equipment and procedural technology that permits direct information transfer between microimage and computer subsystems. One manufacturer, Stromberg-Carlson, has announced a soon-to-be-available (November 1967) system capable of direct transfer from magnetic tape to microfiche utilizing a CRT display at a rate of 5 fiche per minute. Furthermore, the system will incorporate a hard-copy printer, producing 11- x 14-inch material, electrostatically, at an output rate of 60 feet per minute. A sizable amount of attention will continue to be paid to the microfilm itself. The storage problem is also liable to be reduced, quite apart from technological changes, by adherence to the storage standards set by the National Bureau of Standards (NBS) and industrial photographic firms. Adherence to the NBS standards requires conscientious microfile management but should pay valuable dividends. One development that will probably occur during the next five years is the perfection of a stable color microfilm. Too, continued research into undesirable chemical phenomena related to film (silver-halide, Diazo, Kalvar, etc.) aging is likely to lead to less severe storage requirements.

Ultramicroform technology is being vigorously developed by at least one or two manufacturers. Ultramicroform uses reductions of 150 or 200 to 1 instead of the commonly accepted reduction of 19 to 1. The advantages of ultramicroform come from the ability to place more information on a single sheet; this is also its disadvantage. Few documents are large enough to require a full sheet; thus, they share it with other documents. The ultrareduction, however, does allow for extremely inexpensive reproduction, if a large number of copies are to be made. This fact has led to a proposal for the creation of a thousand libraries of one million books in ultramicroform. Such a library would not only be inexpensive from the point of view of the amount of storage required to house it; far more importantly, it would be comparatively inexpensive to create the holdings. The expense of cataloging, creation of retrieval techniques, etc., need only be incurred once.

The initial investment required to implement this proposal would be close to $300,000,000. However, the sparseness of libraries of million-book size makes the proposal important, for providing an economically feasible way of satisfying the need for great libraries, not only within the United States but throughout the world.

The proposal of a million-book library replicated a thousand times assumes that all libraries would have the same base collection. Of course, the concept of the uniform library is not restricted to ultramicroform. It can also be applied to regular microform. In either case, the concept grows more exciting when it is coupled with the possibility of a computer tie-in for information retrieval.

Another advanced library concept involving microforms is represented by a project at M.I.T. and scheduled for operation in about two years. Documents are to be stored on microfiche, and the fiche will be retrieved by computer, viewed with a television camera, transmitted to one of many remote locations, and presented for reading.

Some interest is currently being expressed in microfiche with a reduction ratio of about 50:1. This is less ambitious than the ultramicroform approaches but it has some desirable features for library applications. The fiche would consist of about 13 rows of 30 images each. The title block could contain appropriate normal-reading indexing material, a classification code, title, author, acquisition number, publisher, number of pages, number of fiche, etc., in the same manner, and to the same degree, as the 19X fiche. However, the capacity of the image area would be 390 pages, permitting handling of from 60 to 80 percent of all monographs on a single fiche. (The COSATI fiche handles only 60 images, thus requiring 6 to 7 fiche for a 300-page book.)

Some feel that the potential advantages of a 50X fiche may impel equipment manufacturers and others to advocate this as standard within the next two to five years. One production advantage of the 50X fiche is that unlike other ultramicrofiche it could be produced in a single step, as 45X reductions are currently being done. Another advantage over other ultramicrofiche is that, apart from modification in the frame-locating mechanism of readers, current fiche equipment and techniques for duplication, filing, retrieving, etc. should be capable of handling a 50X fiche quite satisfactorily. Then, too, good reading and printing capabilities should be more easily obtainable than with the 150:1 or higher ratios.

Another microform with considerable potential is "microprint."[2] Microprints are opaque and are produced by a printing (not photographic) process. The microprints use either the 19X or 24X reduction ratios and can be produced by standard printing techniques at an approximate cost of 2¢ each. One great advantage of microprints is that they do not have an emulsion; therefore, there are no problems with scratches. However, use of microprints has been limited because of the difficulties of reading and reproducing opaque materials with current equipment. Their use could be enhanced with development of viewers and reader-printers that provided quality equivalent to that obtained with the transparent microfiche.

C-3 REPROGRAPHY

C-3.1 PRESENT STATUS

The term "reprography" refers to the reproduction and replication of graphic materials. The term is fairly new and comprehends not only conventional printing techniques, including letterpress, offset lithography, and intaglio printing, but also the burgeoning field of copying (duplication). The gradual erosion and blurring of the traditional distiction between printing and copying led to the new designation.

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[2] Microprints are not new, and are in common use in libraries. They still have not fulfilled their true potential of very low cost publication.

Traditionally, printing has been most efficient at high volumes, while copying has been most efficient at low volumes. Also, both the quality of printing and the skill requirements for printers have been much higher than for copying. However, we are seeing an increasing convergence of these characteristics. Copiers are becoming increasingly more capable of handling larger runs with less degradation of output quality. Printing devices are becoming more efficient at low volumes.

Present reprographic techniques are already so efficient, rapid, inexpensive, and acceptable from the standpoint of quality that there is no doubt about their utility in libraries. Present-day discussions of the subject usually concern how much one should pay for a particular amount of quality.

C-3.2 REPROGRAPHY COSTS

To provide a useful frame of reference for understanding reprography costs in relation to library services, we performed a cost analysis of several representative techniques and situations.

C-3.2.1 Representative Techniques

C-3.2.1.1 Copier Processing. Copier quality is such that it can be used only for line work at this time. (However, a few companies have announced availability of a halftone attachment for their copiers.) Copiers can accept color input but cannot reproduce the color. Since the economics of halftone copiers are not now known, only line work was assumed for the costing exercise. Three copier cost sets were used in the analysis:

a. Xerox 2400. This is electrostatic printing, at the rate of 2,400 copies per hour,[3] from single sheets of paper.

b. Copyflo. This is electrostatic printing, from 35mm roll film, at speeds of 1,200 copies per hour.

c. Copier. This encompasses both the gelatin-dye-transfer and the diffusion-transfer-reversal processes. Average speed is 1 page copy per minute (64 seconds).

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[3] All production rates given here are maximum obtainable, but may be unreachable in normal operations because of handling problems, need to reload, etc.

C.3.2.1.2 Offset Printing. Line printing involves plate preparation and printing using offset printing presses. Plates may be paper or metal. The paper plates prepared using electrostatic processes are adequate for line work only. Photo-direct and negative-to-plate processes can be used to provide graphic arts quality on line work, and can handle halftone and color work as well. For the 17-x-24-inch size presses, it is assumed that negative-to-plate processing is used for the plates, and that four separate pages are run simultaneously. Four separate cost sets were used:

a. with electrostatic plate.

b. with photo-direct plate.

c. with negative and metal plate.

d. with negative and metal plate, handling four pages at a time.

C-3.2.1.3 Printouts from Microfiche. The specialized equipment found in reader printers (to handle copying in conventional image sizes stored on fiche) provides capabilities for line work reproduction almost equal to that for copiers. Halftone images may be reproduced that are satisfactory for reading and comparable to photo-direct plates used for printing. Color may be stored on fiche and reproduced either in black and white or in color, although close color registration is not always obtained from current equipment. Three sets of fiche-printer combinations were priced: (Costs for generating a plate from microfiche are comparable to the costs for generating a plate from paper reproducibles; therefore, no separate costs are shown for printing from microfiche.)

a. Fiche created and printed using a reader-printer, such as Recordak Magnaprint, Itek, or 3M Filmac, with the corresponding photographic paper.

b. Duplicate fiche used with the aforementioned reader-printers.

c. Duplicate fiche used with the EL-4 printer and dry silver paper.

C-3.2.1.4 Letterpress and Silk-Screening. Since costs for letterpress and silk-screen printing and processing depend on volume and quality requirements of a particular task, and since the feasibility point for letterpress involves copy preparation as well as printing, this process was not included in the costing exercise.

C-3.2.2 Calculation of Costs

Printing and copying costs are dependent primarily on the quantity of pages, the number of copies of each page, the material to be printed, and the equipment used. The comparisons in Figure 7 are based on copy requirements from 1 to 5,000 pages (impressions). The assumption is made that the machine is fully utilized. This makes it possible to ignore the initial cost of the printing equipment (shown in the right-hand column) for purposes of the analysis. Approximate equipment costs are given only for a comparison of the relative size of the basic investment required. When the equipment is fully utilized, its cost contributes a negligible amount to the per-page cost figures for copies. Thus, the numbers in Figure 7 cover primarily materials and labor. It is understood that individual figures in this table can vary for many reasons associated with a particular installation's operations. Details of specific assumptions necessary to produce these figures are omitted, in the interest of brevity.

C-3.3 FUTURE DEVELOPMENTS

The quality and capabilities of copiers, fiche and other microfilm readers, multilith equipment, etc., have been increasing steadily and this trend can be expected to continue. It is reasonable to assume now that within five to ten years, the following conditions will prevail:

a. Copiers will be economically competitive with offset equipment through 100 copies, and may be competitive through 200 copies of a page. They will be able to reproduce color, halftones, and massive solids as well as fiche readers can display them today.

b. The quality of offset printing will be superior to its present quality, make-ready time will be further reduced, and plate-making from microforms will be more widely used than presently. The ability to handle very high quality printing will be common.

c. Fiche reader-printers will be vastly improved, with cost per impression from fiche-to-paper printers dropping below 1.5¢ per page and perhaps reaching as low as 1¢. Use of color will gradually increase in the first five years, and in the following five to ten years will become widespread and economically competitive with black and white.

d. Development of electrostatic printers, using fiche as the source document, will be the dominant development in the fiche reader-printer and printing field.

	1st Copy, Plate, or Fiche Cost in Dollars	Impression Cost	Total Costs per Number of Copies Indicated											Range of Estim. Equip. Costs per Month
			1	5	10	20	50	100	200	500	1,000	2,000	5,000	
Copiers														
A. Xerox 2400*	.021	.021	.021	.105	.210	.420	1.05	2.10	4.20	----**	----	----	----	$1,100/mo.
B. Copyflo	.029	.029	.029	1.45	2.90	5.80	----	----	----	----	----	----	----	800
C. Copier	.130	.130	.130	.650	1.300									250
Printing														
A. Multi-paper plate	.250	.0075	.258	.288	.325	.400	.625	1.000	1.750	4.000	7.750	15.250	37.750	4,000
B. Photo-direct	.600	.0075	.608	.638	.675	.750	.975	1.350	2.100	4.350	8.100	15.600	38.100	4,000
C. Negative & plate	2.000	.0075	2.008	2.038	2.075	2.150	2.375	2.750	3.500	5.750	9.500	17.000	39.500	4,000
D. 17 x 24 in.***	2.000	.0019	2.002	2.009	2.025	2.050	2.125	2.250	2.500	3.250	4.500	7.000	14.500	10,000
Fiche														
A. Orig. fiche & photo-print	.030	.080	.110	.430	.830	1.630	4.030	----	----	----	----	----	----	1,200
B. Dupe fiche & photo-print	.003	.080	.083	.403	.803	1.603	4.003	----	----	----	----	----	----	1,200
C. Dupe & dry silver	.003	.030	.033	.153	.330	.660	1.650	3.300	----	----	----	----	----	300 - 400

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*Averaged over typical month's operation in a medium-sized company.

**Dashed lines indicate that there is no economic merit in considering this means further.

***Proportionate cost per 8½- x 11-inch page.

Figure 7. Print Cost Comparisons

e. Printing directly from optical storage devices, magnetic tape or holographic devices, and from ultramicrofiche will obtain a state about equal to that of reader-printers today.

f. Printing from digital data on magnetic tape, or from thermoplastic micro-images can achieve major importance. The growth of the Stromberg-Carlson film devices and the development of electron beam recording, etc., indicates the potential of these developments. Cost for generating a page image on microfilm is estimated at 2-5¢ per page. Direct printout from CRT to bond copy is reported to be competitive with offset printing, although copy quality is not as satisfactory.

g. Optical preparation of copy for high-quality graphic arts material under the control of computers (photocomposition), already very practical, will increase rapidly in applications and usefulness. The current price for text material is about $11 to $25 per page, while graphical material, such as flow charts, wiring diagrams, etc., runs closer to $50. The price of processing, and of obtaining microfilm output for subsequent printing, should drop to about $5 to $7 per page, and even less for producing microprints. (This compares favorably with hot-type costs of from $10 per page and up.) Distribution of the microfilm output from this kind of process is scheduled to start within a year or two in some organizations.

C-4 PUBLICATION TECHNIQUES

Several developments in publication technology hold promise for libraries. The most important is probably computer-managed printing, including photocomposition. Also important is the production of massive amounts of textual material in machine-readable form, as a byproduct of the publication process. This means that not as much reliance need be placed on progress in developing optical readers; such progress has been rather slow.

C-4.1 CURRENT STATUS

The publishing industry has long made use of punched paper tape for the transmission of news copy. In the past few years punched paper tape has also seen heavy use as an input to typesetting machines. More recently, computers have been introduced into the publication operation, to reduce the cost of line justification and hyphenation, and many typesetting machines are now being run by the tape output produced by the computer.

Computers are also being used to prepare high-quality reproduction masters at high speed with electro-optical techniques. The process is referred to as "photocomposition." Early photocomposition devices contained many fonts, on one or more optical plates. Light was passed through a character onto photographic film, lenses being used to obtain the proper size for the character and to place it in the assigned position on the film. These techniques produced extremely high-quality print--as good as any hot-lead device--but there was a serious mismatch with computer speed, fewer than 10 characters per second being set.

Some effort has been made to achieve greater speed by reducing the number of characters available for printing purposes, sacrificing some degree of quality for speed. The latest techniques attempt to achieve both high quality and great speed. Light, instead of being passed through individual characters, is created electronically in the proper character shape as an emission from a cathode ray tube. While quality is not as high as the quality of the characters etched onto the photographic plates, the speeds now achievable are commensurate with computer speeds. The printer of this type presently used by the Government Printing Office is capable of setting a full page in five seconds.

Developments in photocomposition are important to libraries not only because they need machine-readable text, but because--quite apart from advanced text-processing techniques--most libraries have a constant printing requirement. The National Library of Medicine, for example, sponsored research on one of the processes described above, and uses it for the publication of Index Medicus, a guide to the medical literature.

C-4.2 FUTURE DEVELOPMENTS

One can expect to see continuing improvement in photocomposition devices. The Government Printing Office is scheduled to install, sometime in 1967, a photocomposition device with a character set of 1024 characters and operating speeds of up to 600 pages per hour. This device is felt to represent a major advance in automated print composition.

The advent of the computer and, to some extent, photocomposition, has spurred suggestions for a return to the publication of book-form catalogs. Many libraries feel that if a card catalog were available in many places other than just the standard card catalog area, the library would receive wider use. Replication of the card catalog itself is not economically feasible. With text in machine-readable form, the production of such catalogs is not technically difficult. But if the library once translated its card catalog into machine-readable form, it would be easy to use the computer to update the machine-readable form of this catalog. This machine-readable record could be used to drive some kind of printing device (line printer or photocomposition) to create an updated version of the book catalog. Very large library collections would require many volumes to contain the catalog record. Since no really large library has its entire catalog in machine-readable form, it is not yet clear what problems will exist for large computer-produced book catalogs that need to be kept up to date, say, on a monthly basis. Other questions concern the number of copies of a catalog required to service users without delays, length of life of a heavily used book catalog, etc. Such questions need to be explored before it will be clear how extensive will be the impact of publication technology on library procedures.

C-5 PHYSICAL HANDLING AND STORAGE

C-5.1 PRESENT STATUS

The book is currently the primary kind of information carrier used in libraries. Because books require physical handling and storage, considerable attention has been given by manufacturers and librarians to the development of aids for these functions.

Materials-handling installations that have been successful in the library are those in which selected library activities are viewed as being similar to those of the wholesale drug and sundries distributors. Their situation requires filling many requests (orders) for small quantities of small items of irregular shape, size, and weight. Libraries have very successfully used containers and baskets in connection with vertical lifts, conveyors, chutes, and pneumatic tubes. These devices move standard-size receptacles after a human handles the books and decides on their destinations. Among the libraries effectively using existing technology in this manner are Detroit Public Library (conveyors, tubes, and lifts), UCLA Library (the same, including an underground tube connecting two distant buildings), and the Technological University Library at Delft, Holland. The latter is a fairly advanced operation of this sort, but it serves only for delivery of books to patrons, not for reshelving.

One new product line, announced in 1966 by the Library Bureau of the Sperry Rand Corporation's Remington Rand Office Systems Division, appears to have considerable promise as a tool for library stack management. It is called the RANDTRIEVER and was originally designed for storage and retrieval of letter-sized document folders in "original-document" filing systems. Basically, the RANDTRIEVER is an automated warehousing system. Items requiring physical retrieval are housed in open-top metal containers large enough to hold 15 letter-size filing folders. Each container is stored in a unique, seven-digit-coded shelf location. Attached to each container is a machine-sensible punched card containing its shelf location code. Shelving modules may be as high as 22 feet, or 20 levels of containers. A moving vertical "master column" extracts and replaces containers, then delivers them to and receives them from one-way conveyors linking the storage area to the control stations. Control station operator consoles accept keyboard, punched-card, or tape inputs for retrieval.

The manufacturer has one system in operation for display purposes at the plant facility. Two have been sold, but are not yet installed; both are for record-keeping rather than library applications. The cost range quoted by the manufacturer is $2.25 per linear inch of shelving. This is quite high, but it may be justified when evaluated in terms of long-range amortization and savings. Clearly, cost justification for this type of system is possible only in high-volume, high-usage collections.

C-5.2 FUTURE DEVELOPMENTS

Several aspects of books limit the prospects for substantial automation of physical handling, for example, the variety of sizes, shapes and weights, and the absence of uniform or repetitive handling of each item. Nevertheless, the outlook for automation is not hopeless, because (1) some devices have been successfully installed in the library; (2) there are ways of tailoring library operations to satisfy some of the physical requirements for automation; and (3) there are some promising materials-handling products of the future.

Countless mixes of existing equipment and procedural technology might be very effectively used for physical handling of books, without unnecessary adverse trade-offs in service to the user. For example, today's technology could offer a system with the following characteristics:

- Books stored in closed or open-top metal containers having unique shelf locations
- Computer record-keeping of container locations
- Computer-controlled display of bibliographic and/or abstract data by either microfilm or cathode ray tube (to provide browsing)
- Mechanical retrieval and reshelving along with conveyor transportation (eliminating the need to "subject-store" books)

The above features are all within the state of the art and require no advances in equipment technology, although admittedly the cost would probably be rather high. It seems likely, however, that existing equipment technology and minimal refinement of existing procedural advances could provide significant operational improvements in some libraries.

On the basis of observation of current developmental work in mechanical materials handling, some projections can be stated for product trends for the next five years that will have application to library book handling. The general approach to materials-handling engineering is likely to be more systems oriented. We may expect to see more installations in which handling equipment, storage equipment, sensors, control devices, and computers will interact under computer monitoring. The computer will be able to manage not only the movement and storage processes but also related inventory data management functions.

Some of these developments will be founded more on procedural advances than on equipment advances. However, there are several specific hardware advances that can contribute to high-level system performance in library book handling. For example, magnetics will be more widely used in the development of sensing devices. Items such as book covers or book containers can be uniquely magnetized for automated identification. The processes in which the payoff for libraries would be the greatest are selecting, sorting, distributing (flow direction), counting, and storing. (Magnetics may also see more use in protection against theft.)

The next ten years will probably also see the development of automatic self-loading equipment designed to handle units such as book containers. Outside the library world, unit-load equipment is not new, nor is its use in automated systems. Mechanized storage rack systems under automatic and semiautomatic control already exist for both palletized and special-shaped goods. Equipment such as the overhead stacker crane is presently operational in such systems. This type of equipment is suspended from overhead monorail or track networks. Its movement is controlled by commands from work station consoles or machine-processable cards, tapes, etc. Floor-running, rack-running (shelf), and overhead-running stackers could be tailored for library use.

The development of improved handling equipment for moving, storing, and locating will require comparable development of control devices and associated instrumentation related to sensing, switching, and directing material flow. Sophisticated electronic, electromagnetic, and electromechanical control devices are being developed and used for industrial material-handling applications, and they presumably will be adaptable to library systems through concentrated product engineering.

The matter of care and preservation of printed materials continues to receive attention. Research efforts concerning the chemical and physical characteristics of paper deterioration have pinpointed the principal cause as acidity in paper itself. The most notable research in this area is that of W. J. Barrow, under sponsorship of the Council on Library Resources. Paper deteriorates not only because of the presence of acid, but also because of the reaction of the paper's acidic chemical content to environmental factors such as temperature, humidity and air impurities. For example, conditions in a geographic area having high humidity and sulfur dioxide in the air result in a deteriorating sulfuric-acid reaction in the paper. Research efforts have shown that controls for air-purification, lower storage temperatures and humidity can prolong the life of paper, regardless of acid content. It has been estimated that unused, nonacidic, manufactured papers, when stored at about 15°F. and 51% humidity, can have a life expectancy of up to 400,000 years. The life expectancy of a deacidified used book stored at 34°F. is 600 years and 4000 years if stored at -2°F.

The technology of caring for existing printed materials should be discussed in terms of preservation vs. restoration. Preservation involves chemical deacidification by spraying the printed page with a magnesium bicarbonate solution to neutralize the paper's acid. The cost for this process is about $2 per volume. Complete restoration involves removing the binding, bathing each page in the solution, laminating the pages, and then rebinding. Costs are usually based on a square-inch basis, since printed materials other than books are also processed. However, a 400-page volume of average page size would cost around $40 to restore (98). At least two firms now specialize in this service. Most libraries could not presently afford the equipment and skills necessary for such operations; those wishing to restore documents would do best to obtain the services from outside.

The problems of caring for deteriorating books has been addressed by the Association of Research Libraries, with financial support by the Council on Library Resources, Inc. ARL has endorsed a proposal whereby a federally supported central agency (newly created or to be established within an existing agency) would insure the physical preservation and low-temperature storage of at least one example of every deteriorating record. Such an agency would also insure either microform or full-size photocopies of deteriorating materials. The cost of the proposed system is estimated at $7.25/volume.

The cooperative interaction of the library community, the paper industry, and the Federal Government will lead towards stepped up activity in two areas. First the development of paper of more enduring physical characteristics will be a major developmental effort. Advances in chemicals used for sizing and other mill processes have already occurred and improved processes will reduce the cost of more durable paper. Further Federal support, such as that provided by the Library Services Act, will probably be needed to accelerate the growth of preservation and restoration of existing printed materials.

C-6 TRANSMISSION OF MATERIALS

C-6.1 CURRENT STATUS

Both current and project library operations involve transmission of materials from the storage location to the user. This can be achieved by local transportation, the U. S mails, or by other techniques such as television or facsimile transmission. Each has technical and cost advantages and disadvantages. Some techniques raise difficult legal issues as well, for example, when published material is transmitted from one computer store to another. The present discussion is restricted to technical and cost issues, particularly as related to some of the more advanced techniques.

The controlling factors in the selection of the transmitting and receiving equipment include the material to be transmitted, the quality of transmission desired, the available interconnections (telephone lines, cables, broadcast, etc.) between transmitting and receiving equipment, and the cost of the interconnections. Typical interconnecting links are standard telephone, telegraph, and teletype circuits; private telephone voice lines; broad-band computer-to-computer circuits; special-purpose television circuits, and microwave relay.

The factors to be considered in planning a library application using transmission equipment as an integral element of the system include:

a. The storage medium for the document (hard copy, microfilm, magnetic tape or disc, in image form, or in digital data form, etc.).

b. Number of access stations and distances between the access stations and the central store.

c. Number of documents to be stored.

d. Simultaneous access requirements (i.e., how many users will be looking at the same document at one time), or total transmission load at one time.

e. Quality requirements of document--number of characters, illustrations, halftones, size of page image, size of type face, etc.

f. Image form desired at output station, e.g., hard copy, microform, image only, or a combination.

g. Cost.

A comparison of current transmission speeds, based on a page characteristic of 60 characters per line and 50 lines per page (a total character count of 3,000) shows that teletype and facsimile (or long-distance xerography) require approximately 220 seconds for the transmission of one page. In contrast, it takes only 1/30 of a second per page for video transmission.

Both the speed and quality of transmission are a function of available bandwidth. Work of the standards committee on image transmission has established a resolution scale, based on examination of 8-point type material, as follows:

100 lines/inch - unsatisfactory

135 lines/inch - marginal

190 lines/inch - fair

Present equipment on voice grade lines produces about 96-line resolution. It is estimated that it takes about 6 minutes to transmit one page at 100 lines; 11 minutes at 135 lines; and 22 minutes at 190 lines. Hence, the cost per page increases 370 percent to obtain a 90-percent increase in quality. Costs, on this limited basis, increase 3 times as fast as the quality (89). However, there is considerable promise in long-distance xerography. Although one study showed a discouragingly high cost ($7.26 for transmitting and reproducing a 10-page document over a 75-mile distance), the technique produces better quality reproductions than ordinary facsimile.

For a given library application, costs per image, per operating hour, etc., can be determined only in relation to a particular configuration of equipment. However, some rough guides to current costs can be given:

a. Books. Mailing costs per book are about 10¢ per book (based on a 4¢/lb. library rate). Time for "transmission" is about 120 hours (5 days). Cost of reproduction (full-size hard copy) of a book of 300 pages can be estimated at $6.30.

b. Fiche. Mailing costs for 5 fiche are 5¢ for first-class mail. Time for transmission is about 48 hours (2 days). Costs of reproducing a set of 5 fiche (into more fiche) can be estimated at $0.75.

c. Facsimile. Facsimile equipment costs for 96-line resolution are approximately $1,800 per month for both transmitting and receiving equipment (assuming one receiving station). Time per page is about 6 mintues, and cost for telephone time can be estimated at $1.50. Printout in hard-copy form is about 8¢ per page. Assuming usage of 170 hours per month, costs for equipment and telephone lines would average about $2.75 per page for cross-country transmission.

d. Video. Video equipment costs for 500-line resolution are approximately $18,000 for transmitting equipment, $12,000 for receiving equipment (buffer, display refresher and display), and about $100,000 per month for rental of a coaxial cable linking points 3,000 miles apart (assuming $35 per mile per month). Transmission speed is at 30 pages per second. If we assume that reading speed is 10 seconds per page, and buffer capability is one page, the transmission requirement is one page every 10 seconds. Costs for that page can be estimated at 3¢ for equipment, and 16¢ for line charges, or 19¢ per transmitted page. Any reproduction of the video image can be accomplished at conventional prices at the receiving facility, or at a hard-copy printout price maximum of 8¢ per page.

None of these prices include maintenance of equipment, and supplies for that equipment. Maintenance of the video equipment can be extremely expensive, perhaps 25 percent of the yearly equipment costs.

In general, one can say that fiche provide the lowest cost per page transmitted and that video equipment, while providing low per-page costs, does require a large capital investment. (However,costs for line charges in a video system can be reduced from the maximum distance cost of 16¢ per page to an estimated cost of one cent per page for short-distance transmission.) It is clear that a cost/effectiveness study, including some analysis of the relative value of information obtainable within 48 hours, versus, say, one second, certainly must form a part of any planning for the improvement of library service.

C-6.2 FUTURE DEVELOPMENTS

In general, it is expected that both the accuracy and the data-transmission rates of various kinds of telecommunications equipment will increase in the near future (25). Communications satellites, which are currently in a development and testing phase, can also be expected to have some potential as a medium for transferring documentary information. What is not yet clear is whether there will be sufficient integration of the various kinds of transmission media and networks to serve the purposes of a more highly integrated library network. Even though an organization (the National Communications System) was established in 1963 to help coordinate the planning and optimized use of Federal telecommunications resources, there does not yet exist a truly integrated, compatible Federal telecommunications network.

Several programs are under way to develop working systems for retrieving from a central store, transmitting the image to a different location, and viewing the image at that location. For example, one objective of Project Intrex is to provide unlimited access to the MIT library collection of one million books. There is to be

- guaranteed rapid access to the entire data base (i.e., full text) from every console,
- rapid transmission of the data on request (at 1/2 second per page), and
- high-quality displays, including engineering drawings, mathematical expressions, foreign languages, and special symbols.

The system is intended to have the ability to advance page images (turn pages) of the book being read, by button action at the remote receiving console, and to supply supplementary hard copy or microfilm, if needed.

Several other organizations are also working along somewhat similar lines. RCA is requesting permission to experiment with newspaper or book page image transmission, using standard commercial television channels, and modified home TV sets. Use of the set for viewing text images in not expected to make the set unusable for conventional TV. Bell Telephone is working toward establishment of regional data centers for engineering drawings, which will be available on demand to each of the engineers and draftsmen within that region. The Navy Department's Bureau of Ships has installed a system for transmission of maintenance data from shore to ship, using microwave relay techniques.

On the assumptions that more and more serials will be published in microfiche form and that portions of the report-type literature will be almost completely microfiche, it seems feasible to equip some local libraries with remote consoles, using video displays. Present techniques and equipment could be utilized to provide a significant number of local libraries with up to 100 display and inquiry stations. These stations would have to be located within about .2 mile from the computer, to avoid special coaxial lines and booster circuits. With a concerted effort, it would be possible to convert 40 to 60 percent of the nation's libraries to the use of remote display stations within 10 years. Needless to say, the source documents would also have to be converted within the same time limits to provide compatibility between old and new materials.

It also seems feasible to provide video communication links between local and regional libraries. If, later, regional libraries could be linked, it would be possible to view documents, with minimum delay, from any repository within the network. Transmission costs from a regional library to another regional library, and then through a local library to a local viewer, can be estimated to be somewhat under 30¢ per page. If the image were put on microfiche at the receiving library (or at any point on the circuit) at about 3¢ per page, subsequent viewing costs would be quite minimal. The quality of the images thus obtained is difficult to predict; it would be worth some experimentation here to provide a better basis for speculation.

In spite of the promise of this new technology, it seems unlikely that, for the next ten years (or longer), libraries will, or should, expect the dominant storage medium to be other than books and the dominant transmission medium to be other than the U.S. mail. This is the one existing network that can support the materials transmission needs of all libraries, regardless of the extent to which they choose to cooperate, amalgamate or join in an "integrated" national system.

C-7 LASER TECHNOLOGY AND HOLOGRAPHY

C-7.1 INTRODUCTION

The laser contains a material that can be handled in such a way that its energy is released at one time (rather than in random sequence), and at nearly the same wavelength (color). Furthermore, and particularly important from the standpoint of future library technology, the light is coherent, or, from the wave-theory point of view, in-phase. This coherence causes two important effects: The first is that light is emitted in a narrow beam, which makes the laser potentially useful as a data transmission carrier. The second is that it can be used for a type of photography know as holography, which provides the ability to record many items, or many views of a single item, on a single, small surface.

C-7.2 LASER DATA TRANSMISSION

The advent of laser technology promises a tremendous increase in what, before satellites, had been thought of as an already overcrowded communication capacity. The nearly instantaneous transmission of information over a distance is dependent upon electromagnetic radiation, that is, light and radio waves. The four primary ways of transmitting such information over long distances have been: (1) through the use of electromagnetic radiation, propagated through the space between the receiving and transmitting stations; (2) through coaxial cable; (3) by point-to-point microwave relay (which in functional terms is equivalent to transmission by coaxial cable); and (4) by piping the electromagnetic radiation through cylinders known as wave guides. Technique (1) requires use of a certain band within the electromagnetic spectrum,and no one else can use this band within the energy range of the emitted radiation without causing interference for both himself and the other sender. The other three techniques are more directional and use much narrower channels, but they are also much more expensive to use.

The advantage of the laser beam is that it provides a wireless straight cable, on which it seems possible to impose signals. These signals can be carried along the surface of the earth or by repeat transmission from satellites. Though the results of laser research have been exciting and promising, the work is still experimental and there are many problems still to be solved in the modulation of the laser beam so that it can carry information. We still do not know when this experimental work will have advanced the techniques to the point where they will be useful and economical for library applications.

C-7.3 HOLOGRAPHY

Holography, the other aspect of the new laser technology that may have important results for libraries, is quite different from regular photography. The result of regular photography is a picture that one observes by looking at the plane surface of a photographic plate. In holography, one looks through the plane of the plate, so to speak, and sees an image on the other side of the plate. The image is presented as if it were a real object, that is, the image is seen three-dimensionally. If one looks from a particular vantage point, one part of the image might block out another part. As one changes the angle of view, by moving one's head or the plate, one can see what had previously been blocked.

The hologram is produced by recording onto the photographic plate the wave lengths (technically, the interference patterns) reflected from the object being illuminated by coherent light. Reading out is, in a sense, simply the reverse process: the plate is illuminated by the same wave length (color) as when the picture was taken, and one has the same effect as seeing the original scene. For library purposes, this has many potential uses. One is in storing multiple images on one photographic plate. This is, of course, something that can already be done--though with a radically different technique--on microforms. It can also be accomplished with the new but untried technique of multiplex photography. However, a few investigators believe that the hologram has very great potential for high-density storage and retrieval applications.

A more novel use of holograms in libraries would be for the storage of color pictures of three-dimensional objects. Each hologram plate would contain many views of the object, seemingly from different angles, but actually taken with one exposure of the plate. If this technique were perfected and made economical, one could well imagine greatly improved collections, in libraries, of representations of statuary and other three-dimensional works of art.

It is important to note that there are many research and engineering problems to be solved before holograms can be used in libraries. We have no way, as yet, of predicting when these problems will be solved. Thus, the techniques to be considered for the immediate future are the more conventional methods of photography discussed in previous sections.

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ABSTRACT

The basic objective of this report, prepared for the National Advisory Commission on Libraries is to assist the Commission--and, through it, other interested audiences--in examining the applicability of technology to libraries, possible library systems of the future, and problems of effecting a transition between the present and the future. The report identifies a series of recognized or assumed service and operations requirements, surveys major technologies applicable to libraries, and reviews current and planned applications of technology. Particular areas or functions in which the potential of technology has not been adequately explored are identified, and estimates are given of the likely role of technology in libraries some five to ten years hence, both with and without some kind of accelerating influence. Some of the issues and problems associated with charting and implementing an effective course of action are examined, and a program of action is outlined and recommended for implementation. The program covers five recommended "high-impact" network and systems projects, together with a supporting program of technology-oriented library research, development, education and training. Establishment of a permanent body is recommended to plan and manage these and other programs for nationwide library improvement.